
SUDAN GOVERNMENT

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MINISTRY OF AGRICULTURE

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ANNUAL REPORT
OF THE
RESEARCH DIVISION

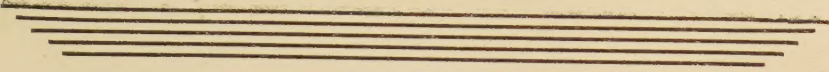
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1951/52

McCorquodale & Co. (Sudan), Ltd. (6011)

1954





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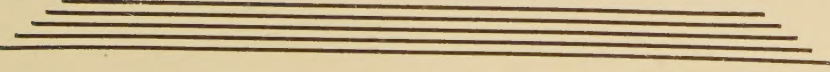
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RESEARCH DIVISION

LIST OF SENIOR STAFF IN SEASON 1951/52

Chief, Research Division	R.C. Maxwell-Darling, M.A.
Asst. Chief and Chief Chemist	T.N. Jewitt, Ph. D.
Inspector, Administration	<i>Vacant</i>
Librarian	W. J. Plumbe, F. L. A.
Statistician	J. Taylor, M. A.
Inspector, Plant Propagation	C. G. Webster

Agronomy and Plant Physiology Section

Chief Agronomist	H. Ferguson, B.Sc. (Agric), N.D.A., N.D.D.
Senior Agronomist	S. Gray, B.Sc., Dip. Agric. Sc. (Cantab), Dip. Agric., A.I.C.T.A.
Agronomist	H. D. Fowler, B.Sc.
Plant Physiologist	C. Coburn, M.Sc.
Farm Manager	M. C. Hattersley.
Inspector, Agronomy	Khalid Saleh.

Botany and Plant Pathology Section

Plant Pathologist	S. A. J. Tarr, B.Sc.
Economic Botanist	K. W. Jones, M.Sc.
Plant Pathologist	<i>Vacant</i>

Cotton Breeding Section

Chief Cotton Breeder and Genetecist	R. L. Knight, O.B.E., M.Sc. (Agric), D.Sc. Ph. D., A.I.C.T.A., Dip. Agric. (Wye).
Asst. Chief Cotton Breeder	M. F. Rose, M.A. (Cantab), A.I.C.T.A.
Cotton Breeder	L. C. Hughes, B.Sc.
Cotton Breeder	K. C. Barlow, B.Sc. (Agric.).
Economic Genetecist	J. E. W. Sadd, B.Sc.
Senior Cytogenetecist	H. Douwes, Ph. D. (Groningen).
Cytogenetecist	R. L. Cuany, B. A. (Cantab).
Inspector, Cotton Propagation	Mohammed Taha el Faki

Entomological Section

Government Entomologist	R. V. Joyce, M.Sc.
Entomologist	D. G. Pollard, B.Sc.
Entomologist	A. T. Goodman, M.Sc.
Senior Forest Entomologist	F. G. G. Peake, M.A. (Oxon), M.Sc. (N. Z.).
Inspector, Pest Control	Bashir Babikir el Shafie
Inspector, Plant Quarantine	Ahmed Mohammed el Makkawi
Entomologist (Locust Research)	H. J. Morris, M. A. (Oxon).

Soil Research Section

Chief Chemist	T. N. Jewitt, Ph. D.
Chemist	T. A. Jones, B. Sc., A.R.I.C.
Chemist	K. R. Middleton, B. Sc., A.R.I.C.
Chemist	J. K. Henderson, B. Sc.
Inspector, Soil Survey	Mohammed Abdel A'al

Yambio Experimental Farm

Senior Research Officer	P. de Schlippe, A. G. (Gembloux).
Agronomist	K.R.M. Anthony, B.Sc., A.I.C.T.A.
Entomologist	E. M. McDermid, B. Sc.
Chemist	<i>Vacant</i>

Central Rainlands Research Station

Senior Research Officer	A. H. Bunting, M. Sc., Ph. D.
Agronomist	J. R. H. McCallum, B. Agr., Dip. Agric. (Cantab).
Entomologist	W. S. Richards, M.A., Ph.D. (Oxon).
Plant Breeder	P. D. Walton, B. Sc.
Botanist	<i>Vacant</i>
Chemist	<i>Vacant</i>

GLOSSARY

1 Feddan	=	1.038 acres = 4200 sq. metres.
1 Rotl	=	0.99 lbs.
1 Kantar of Seed Cotton	=	315 rotls.
Abu Ashreen	=	A watering channel leading from a large canal.
Abu Sitta	=	A small watering channel leading from an abu ashreen.
Angaia	=	Sub-division of a plot of land bounded by a gadwal and a tagnet.
Anis	=	The grass <i>Sorghum purpureo-sericeum</i> , Aschers and Schweinf.
Asal	=	Honey. Term used for stickiness on plants.
Beladi	=	Native.
Berseem	=	Lucerne (<i>Medicago sativa</i>).
Bildat	=	Land, usually near a village, which is cultivated for several years in succession.
Dukhn	=	Bulrush millet (<i>Pennisetum typhoideum</i> , Rich).
Dura	=	Giant millet (<i>Sorghum vulgare</i> , Pers.).
Gadwal	=	The smallest watering channel, leading from an abu sitta on to the land.
Gassab	=	Dura stalks.
Goz	=	Sandhill.
Hafir	=	Pit dug in the ground to collect rain water for use in the dry season.
Harig	=	A system whereby old, dry grass is burnt to kill off germinated weeds before sowing the crop.
Hawasha Hosha	}	= The unit holding in the Gezira Scheme. In the case of cotton, 10 feddans.
Kharif		
Khor	=	Watercourse with seasonal flow.
Komodob	=	Land under crop, which also bore a crop in the previous year.
Lubia	=	The fodder bean, <i>Dolichos lablab</i> , Linn.
Number	=	Unit of land irrigated by an abu ashreen in the Gezira Scheme, usually 90 feddans.

Sagia	=	Land watered by a water wheel, or the water wheel itself.
Seluka	=	Native sowing stick.
Tagnet	=	Ridge for controlling watering.

Abbreviations.

G.R.F.	=	Gezira Research Farm.
k.p.f.	=	Kantars per feddan.
r.p.f.	=	Rotls per feddan.
G.O.T.	=	Ginning out-turn (as percentage of seed cotton).
S.E.	=	Standard error.

RESEARCH DIVISION

MINISTRY OF AGRICULTURE

ANNUAL REPORT FOR 1951/52

INTRODUCTION

Staff

Dr. F. W. Andrews, Chief Economic Botanist, retired after 22 years service. An early worker on blackarm disease, he also did much work on control of nutgrass and water weeds; his last work completed after his retirement was the production of a new Flora of the Sudan. Mr. R. R. Anson, Chief Cotton Breeder, also retired during the season and was replaced by Dr. R. L. Knight. Mr. Anson was 16 years in the Sudan, and established the cotton breeding work in the Nuba Mountains. Mr. T. O. Harding, Inspector (Administration), retired after 24 years service in the Sudan. He gave invaluable service during his years with the Research Division, relieving the Chief of practically all administrative work. Mr. W. J. Plumbe resigned after 4 years work during which he organised the library efficiently on modern lines.

Dr. A. H. Bunting joined the Division as Senior Research Officer in charge of the new research station for the central rainlands, and Mr. J. R. H. McCallum transferred from the Field Division as Agronomist. Tozi Research Farm, as the new station is named is 8 miles west of the Blue Nile, on latitude $12^{\circ} 30'$. It has been established with temporary buildings with considerable difficulty owing to its isolated situation, and work will start on a small scale during the rains of 1952. The scientific staff for the station is now 4 and 2 more are expected during 1952; there are also 2 vacancies which it is hoped to fill.

The entomological vacancy has been filled by Mr. A. T. Goodman who is working on cotton problems at Tokar. Mr. H. J. Morris has been appointed for research on the desert locust; this post was approved in 1948 when the East African Desert Locust Survey was instituted, but was only filled this season. Ahmed Eff Mohammed el Makkawi was promoted to be Inspector, Plant Quarantine Service. Mr. E. N. McDermid was appointed as entomologist for Yambio Experimental Farm.

Egyptian Cotton.

YIELDS

The yields in the last seven seasons have been as follows in kantars of 315 rotls per feddan of seed cotton.

Season	1945/46	46/47	47/48	48/49	49/50	50/51	51/52
Gezira ...	3.36	3.93	3.39	4.26	4.58	6.78	3.10
Gondal ...	4.73	3.26	3.81	4.35	2.45	6.85	2.16
A/Magid ...	3.00	3.60	3.07	4.01	4.61	5.75	2.42
Dueim ...	2.22	2.72	2.83	3.75	3.98	5.59	2.96
Fatisa ...	1.95	1.92	3.62	4.69	4.48	6.21	3.01
Hashaba ...	2.00	1.64	4.01	4.46	4.32	5.80	2.64
Um Gerr ...	2.69	3.78	3.25	4.37	4.67	6.82	3.34
Wad Nimr ...	3.32	2.83	2.91	5.81	6.37	9.30	3.57
Tokar ...	2.27	1.81	2.40	1.35	1.13	1.74	0.66
Gash ...	1.52	1.81	2.20	2.23	2.30	1.42	1.67

After the record high yield of the previous season the yield of the Gezira fell to 3.01 k.p.f., which is the lowest yield since 1933/34 though 1943/44 approached it with 3.17. The grade also was very poor. The White Nile Schemes followed the same pattern.

The good rains of 1950 and the poor July-15th August rains of 1951 (a record low at the G. R. F.) were both factors unfavourable to yield and the estimate from the rainfall equation was 1.94. This would not take into account the beneficial effects of spraying against jassids and the application of nitrogenous fertilizer since these operations were not done during the period which was used in working out the rainfall correlation. A "corrected" estimate to allow for these factors was 3.07 k.p.f. (p. 16).

An interesting point is that the 2 Blocks of the new North West Extension averaged 5.24 which was outstanding for this season. As these Blocks were under Sakel, these yields were probably responsible for the fact that Sakel outyielded X1730A, taking the average for the whole Scheme.

Diseases and pests must have played a large part in reducing the yield and the amount and incidence of weeds, caused by the late start of the rains, were major adverse factors at the Research Farm and this must have applied to much of the Scheme as well (p. 16).

39000 feddans were flooded in the Gash Delta and produced a poorish yield. At Tokar only 9700 feddans were flooded sufficiently for cotton to be sown. Later there were heavy rains and a further 23500 feddans were sown; this was practically a failure but its yield was included with that of the flooded land. The figure of 0.66 is therefore misleading and not comparable with the yield of previous years.

GEZIRA WEATHER

The July-15th August rains were very light, and the rains really began only in the second half of August. The late rains, in September and October, were heavier than usual. Temperatures during this period were higher than usual in the dry part and somewhat lower in the rainy part of the period. The winter began with a cool November, and December was much colder than usual, the latter half being very cold for these latitudes. January temperatures were about average but the humidity was high. February was hotter than usual.

PESTS AND DISEASES

Gezira.

Flea beetle damaged the seedling cotton severely in many parts, as usually happens when the rains are late. Blackarm appeared on the young cotton including the blackarm resistant X1730L-1, but this made a better recovery than the susceptible X1730A. The disease was much more widespread and heavy than for many years, though the symptoms were in general not nearly as severe as in the bad seasons of the early thirties. The early colonisation of cotton by jassids was on a smaller scale than in the year before but their build up was more rapid. There appeared to be a certain amount of reinfestation as more sprayed cotton than usual showed some damage. This is unusual in the Gezira where early spraying usually gives the best results. But in the exceptional rainfall conditions of 1951, when weeds on the fallows were still growing in October in some areas, reinfestation might well have occurred. Numbers on the cotton before spraying were less than in the previous season, but the maximum population on unsprayed cotton was greater. Severe defoliation was caused by thrips in many areas in October. DDT is very effective against thrips but the jassid spraying does not always control them, although it could be expected to do so considering its time of application and length of residual effect. This will be investigated. The last insect of importance in 1951/52 was the cotton whitefly. The infestation by this pest was on an unprecedented scale and it must have been responsible for most of the leaf shedding and perhaps the wilt which took place in November and December. Whitefly also ruined large areas of lubia (*Dolichos*) which has never been recorded before. Leaf curl, like blackarm, was worse and more widespread than for many years, but again the number of plants showing severe symptoms was much less than in the bad, early years. The reasons for the prevalence of the diseases are given on p. 72 and p. 73.

Gash and Tokar.

Bollworms were not bad in the Gash during the season. Considerable shedding of buds and bolls was caused by American bollworm and *Creontiades* at Tokar, but most of the shedding of bolls — the most important loss — was not due to insects.

Experiments.

A large scale experiment with parathion against whitefly gave promising results but the spraying was apparently done too late, as the population declined on the controls as well as on the sprayed areas (p. 123).

Treating cotton seed with insecticides was unsuccessful as a control of flea beetle (p. 125), while DDT proved superior to BHC, Aldrin and Dieldrin against jassids (p. 126). Comparison of spraying with certain land machines and aircraft showed that they were all effective, with little to choose between them (p. 126).

Investigations were begun again at Tokar to try and elucidate the cause of shedding. The impression is that, while considerable shedding is associated with attack by insects, the main cause of shedding is physiological, possibly caused by the cloudy weather which prevails at Tokar during the growing season (p. 136).

Investigations on bollworms in the Gash were begun. Their pest-status and biology was studied and a field experiment with DDT was unsuccessful in controlling them. A large number of preliminary trial with various insecticides were carried out (p. 155).

New chemicals for disinfecting cotton seed against blackarm were tried and some showed promise (p. 77). It was confirmed experimentally that later sowings were less likely to get blackarm (p. 78).

Weed killers were tried as a method of preventing the growth of cotton ratoons; although quite a high measure of control was achieved it was not high enough (p. 78).

WORK ON NUTRITION OF COTTON IN THE GEZIRA.

Most of the nutritional work was on phosphorus. The results of the long term NPK experiment have been analysed and the main effect of phosphorus gives a significant increase in yield of 0.27 k.p.f. (p. 39). The lower levels of nitrogen application give the best response in years of high rainfall (p. 38). In some years the phosphorus content of the leaves is correlated with yield (p. 39).

AGRONOMY EXPERIMENTS.

The long term experiments at the GRF gave in general the results expected.

Response to nitrogen applications was good and much higher than in the commercial crop. Spraying of urea did not increase yields and this agrees with previous experiments in spraying ammonium nitrate (p. 25).

The yields in the organic manure experiments were very high for this poor season as they also were for the previous very good season. But the response to the various manurial treatments was not particularly large and not always significant. The reason for the overall high yields of these experiments is therefore unknown (p. 20).

Another experiment using an overhead sprinkler to simulate rainfall was carried out. No effects from the treatment were observed, although the small pre-sowing rainfall meant good conditions for the experiment, as was also the case in 1949/50 when the first sprinkling trial was done (p. 26).

COTTON VARIETIES.

The cotton breeding programme continued on the usual lines. BLR. 14/25 which is designed as a Sakel resistant to blackarm and leaf curl has still insufficient resistance to leaf curl (p. 81 and 87). Work was begun on selections for salt-tolerance and breeding for lint which would not easily be blown out of the boll (p. 83).

In variety trials in the Gezira the blackarm resistant types showed up well when the disease was present. (p. 84).

The transference of hairiness to Sakel for jassid resistance is proving complicated (p. 90).

The report of the cytogeneticists is included for the first time (p. 92).

American Cotton.

YIELDS (K.P.F.)

The yields during the past 4 seasons were as follows.

	1948/49	1949/50	1950/51	1951/52
Zeidab (irrigated)	3.60	3.78	4.00	3.18
Kordofan (rain grown)	0.98	0.84	0.81	1.39
Equatoria („ „)	1.13	1.20	1.46	1.11
Other („ „)	—	—	—	0.67

(mainly Gedaref District).

In 1950/51 the area sown in Kordofan was 116900 feddans, but the rains were too heavy and there was much waterlogging in the heavy soil. Blackarm was worse than for several seasons. These factors resulted in a rather poor yield. In 1951/52 the area sown increased by 42000 feddans and the yield was a record, owing to well spaced rains. Blackarm was less severe. Bollworms have not been bad during the last 2 seasons and this can probably be attributed to the improvement in phytosanitary measures.

The cotton area in Equatoria increased from 17600 feddans in 1950/51 to 22700 in 1951/52. The yield was not good owing to a drought in the middle of the rains and heavy late rains which damaged the early pickings. These conditions however favoured Meridi District where late sowing is generally practised. Pests were worse this season, mainly pink bollworm and stainers; blackarm was frequent on the leaves of young plants but apparently did little damage.

Some 9000 feddans of cotton was grown on rain in Gedaref District. Some of this was under marginal conditions and yields varied from 0.1 to 1.5 k.p.f. Apart from rainfall, thrips are the limiting factor in this area and it is not worth growing cotton unless it can be sprayed. Blackarm did serious damage in some places.

EXPERIMENTS.

A weeding trial at Kadugli indicated the value of early weeding over late weeding (p. 98).

In Equatoria sowing cotton in association with groundnuts or soya gave fair yields of both crops with less work than is necessary for their cultivation separately (p. 178). Plant observational work was started in Equatoria (p. 179).

COTTON VARIETIES.

BAR. 11/5 is being bulked at Yambio to replace BAR. SP 84 as the commercial strain. BAR. 7/8 yielded best at all three variety trials in the Nuba Mountains (p. 98).

Other Crops.

Observations on alternative cash crops for the Gezira were continued (p. 29). Rice and sugar cane were unsuccessful.

Lubia, which with dura stalks comprises the main fodder of the Gezira, was mostly very poor in 1951/52 largely owing to whitefly. Trials with various other legumes were continued and *Clitoria ternatea* appears most promising (p. 34).

Attempts to find a suitable dura and a suitable way of growing it in the wetter parts of Equatoria have so far failed (p. 181). Fertilizers applied to the bush in August 1950 seemed to have an effect on ground-nuts planted in April 1951 but this was not significant (p. 183).

The grasshopper *Aiolopus savignyi* again damaged dura in Gedaref District. Application of BHC with lubia seed when sowing was successful in controlling cochchafer larvae and increasing yields (p. 133).

Progress was made in the second season of plant breeding of crops other than cotton (p. 101). This work has been transferred to the new Central Rainlands Research Station.

Miscellaneous.

WEEDKILLERS.

Chemical weed killers were tried in the rainlands, the Gash Delta, and the Gezira to control weeds before planting the crop. Considerable success was obtained but the question of relative costs has not been investigated. The weed killers were not successful in the Gash Delta probably because the chemicals got washed too deep in the permeable soil (p. 61).

The hope that 2,4-D would solve the problem of floating weeds in canals has not been realised (p. 65).

MCPA and 2,4-D show great promise for the control of the parasitic plant *Striga* which is an important pest of dura (p. 69).

SOIL RESEARCH.

Large scale soil surveys of areas commandable by the Niles were continued (p. 163).

Nitrates in the surface soil of the Gezira were high in August as was expected owing to the light rainfall. At the same time there are indications that the uptake of nutrients by the young plant was greater than in years of high presowing rains and high yields (p. 166).

Examination of deep holes at Yambio did not show evidence of phosphate accumulations deep in the soil (p. 171).

ECOLOGICAL WORK.

Regeneration of natural vegetation on cleared land was studied in Equatoria (p. 185). Results are of interest in connection with the preservation of bush from fire and thus possibly restoring or preserving the fertility of the soil.

Publications During 1951.

- Darling, H.S. Insects and Grain Storage in the Sudan. (Sudan Notes & Records Vol. 32, Pt. 1, pp. 131-149).
- Darling, H.S. Pink bollworm, *Platyedra gossypiella*, Saund. at Zeidab, Northern Sudan. (Bull. Ent. Res. 42, Pt. 1, pp. 157-167).
- Ferguson, H. Sugar Cane Trials of the Flood Plains of the Bahr el Jebel in the Anglo-Egyptian Sudan. (Ministry of Agriculture, Sudan Government, Bulletin No. 6).
- Hattersley, M.C. Kenana Cattle at the Gezira Research Farm. East African Agric. J., 17, pp. 27-31.
- Rose, M.F. The Nuba Mountains Cotton Crop. Some factors affecting yield. (Emp. Cott. Gr. Review, 28, No. 2, pp. 1-11).

R. C. MAXWELL DARLING
CHIEF OF THE RESEARCH DIVISION.

7th September 1953.

AGRONOMY AND PLANT PHYSIOLOGY SECTION

I. Climate

The unique feature of the 1951/52 season was the exceptionally low rainfall throughout the Gezira, and especially in the south and centre. The G.R.F. rainfall was a record low, both total, and July 1st — August 15th. Table 1 gives the monthly rainfalls for 1951 and for the two previous seasons. Tables 2 and 3 give further meteorological averages for the same three seasons.

Table 1.

Monthly Average Rainfall at the G.R.F. (mm.).

Month.	1949	1950	1951	Average 1919—1942
April	—	9.4	—	3.3
May	50.0	5.4	14.0	11.2
June	36.7	24.4	11.8	33.3
July	48.1	149.6	29.7	132.2
August	47.4	101.4	125.1	146.1
September	57.2	83.7	37.4	55.5
October	8.0	42.6	19.5	13.3
November	—	—	—	1.1
TOTAL	247.4	416.5	237.5	396.0
July 1st—August 15th.	68.3	180.5	48.7	215.0
—August 16th		(217.3)	(49.2)	

Table 2.

Evaporation (Piche') at G.R.F. (mm.).

Month	1949	1950	1951	Average 1919—1942
April	23.4	21.5	22.1	23.0
May	19.1	21.2	17.9	20.3
June	19.2	19.5	19.4	18.6
July	15.9	8.6	14.8	11.7
August	9.5	5.3	10.3	7.1
September	9.4	6.7	8.2	8.3
October	12.0	10.7	10.6	11.9
November	15.3	13.5	13.9	14.9
December	12.9	12.4	11.4	14.4
	1950	1951	1952	
January	15.1	13.3	13.8	15.3
February	17.0	15.9	16.5	17.9
March	21.4	20.7	20.4	21.2
Total for year	190.2	169.3	179.3	184.6
Total till end of Nov.	123.8	107.0	117.2	115.8

Table 3.
Maximum and Minimum Temperatures at G.R.F. (°C).

Month	Maximum				Minimum			Av. 1919— 1942
	1949	1950	1951	1919— 1942	1949	1950	1951	
April	40.5	41.1	40.0	41.1	20.0	22.5	17.0	20.9
May	40.6	41.7	40.7	41.0	23.9	23.9	24.6	23.7
June	39.7	39.9	40.3	39.7	24.0	25.3	23.6	24.4
July	37.7	34.6	37.2	35.6	23.9	21.7	23.6	22.5
August	35.8	32.1	35.3	33.5	22.1	21.7	22.4	22.0
September	36.0	34.6	35.1	35.8	21.5	21.3	21.9	22.0
October	38.6	37.8	38.1	38.5	21.7	21.2	22.3	21.9
November	36.7	36.5	36.1	36.8	17.7	18.3	16.9	18.2
December	31.5	34.4	30.4	34.5	11.8	14.5	10.1	15.2
	1950	1951	1952		1950	1951	1952	
January	34.3	34.6	33.9	33.9	13.9	13.5	14.4	14.2
February	35.0	34.8	36.4	35.4	14.5	12.9	15.4	15.1
March	38.5	38.6	37.7	38.4	18.4	17.7	17.1	17.7

It will be seen that, in contrast to 1950/51, the months of November and December were very cold. In order to measure the intensity and duration of hot spells and cold spells the total number of degrees recorded above 35°C and below 15°C are given in Table 4. In seasons such as 1950/51 there was much less variation between daily temperatures, a feature which is lost in monthly averages but demonstrated in Table 4. This variation and the accompanying spells of hot or cold weather is probably a most important aspect of temperature in relation to plant growth.

Table 4.
Total No. of Degrees per month

Month	Max. above 35°C.			Min. below 15°C.		
	1949	1950	1951	1949	1950	1951
April	164.9	189.9	151.2	2.5	—	16.1
May	174.5	208.4	176.9	—	—	—
June	142.2	151.0	158.6	—	—	—
July	95.9	22.2	78.1	—	—	—
August	45.5	0.9	43.7	—	—	—
September	54.0	21.6	29.6	—	—	—
October	110.9	90.5	97.3	—	—	—
November	68.1	53.1	37.2	13.9	3.2	8.9
December	0.5	10.7	0.6	103.7	31.0	152.9
	1950	1951	1952	1950	1951	1952
January	26.6	21.0	32.8	54.1	55.8	50.9
February	32.0	20.7	60.8	36.0	73.4	38.7
March	108.2	110.9	92.9	7.8	20.3	15.0
Total	1023.3	900.9	959.7	218.0	183.7	282.5
Total Aug. March	445.8	329.4	394.9	215.5	183.7	266.4
Total Aug.-Oct. ...	210.4	113.0	170.6	—	—	—

The season was one of the worst on record for cotton growth. Both rainfall factors were adverse and pest, weather and other factors were all detrimental to growth and yield. The crop throughout the Gezira was a poor one, and that at the G.R.F. was the lowest on record. Other summer crops were in general poorer than usual, though dura was about average. Winter crops (wheat and safflower) were excellent.

Pests and diseases were severe in cotton and other crops. In the case of cotton this was in part a legacy of the immense crop and relatively poor clean up of the previous season. In the case of other crops lack of natural vegetation undoubtedly caused a concentration on these crops.

II. Cotton and Associated Crops

By H. Ferguson and S. Gray

ESTABLISHMENT, GROWTH, YIELD AND GRADE OF 1951/52 CROP.

The average yield at the Gezira Research Farm was the lowest on record; 2.50 kantars per feddan. Table 5 gives a comparison with previous yields.

Table 5.
G.R.F. Cotton Yields
k.p.f.

Season	Sakel	X1730A	Mixed	American	Av. all varieties.
8 year average	3.97	5.24	—	—	(4.408)* (100)
1946/47 V. good season	3.70	6.32	4.01	—	5.39 (122)
1947/48 F. poor season	2.57	4.31	4.25	—	3.93 (89)
1948/49 F. poor season	2.91	4.44	3.24	—	4.03 (91)
1949/50 F. good season	3.37	5.28	3.12	—	4.63 (105)
1950/51 Excellent season	5.74	7.75	5.23	5.10	6.95 (158)
1951/52 V.V. bad season	2.23	2.53	3.00	—	2.50 (57)

* For "Standard Agronomy Area".

The July till 15th August rainfall was only 48.7 mm. (record low) and this coupled with the good rains of 1950 resulted in both rainfall factors being adverse. Even so, the yield was lower than that estimated from these factors. The extremely poor yield was in the main due to the exceptionally low yields of the main crop hoshas which constitute about half of the farm area, and to some relatively low yields of experimental Sakel. Apart from these, the yields of experimental plots were not lower than was expected for the season, and in fact some were quite high, the highest being 7.87 k.p.f.

The main factor causing the very low yields in the G.R.F. main crop was without doubt the excessive growth of weeds which came up with the cotton. In seasons of normal July-August rains these weeds come up before sowing and are disposed of cheaply and effectively by the reridging before cotton. Shortage of labour and continued wet weather delayed weeding and increased the adverse effect. Priority was always given to experimental plots so that the main crop suffered most.

Pests and diseases were also more severe than usual. Blackarm caused widespread damage, and leafcurl was more abundant than in recent years. Wilt and whitefly were worse than usual, the latter being very severe. Jassids were present, and must have done considerable damage in unsprayed plots. At Hag Abdulla Gezira Observation Plot thrips were very severe, also wilt and whitefly.

Apart from the heavy infestation with pests and diseases the crop appeared to show poorer than usual recovery from them, and there was certainly none of the late growth so characteristic of the 1950/51 season. Investigations at present being carried out on temperature effects show that poor July-August rains are correlated with spells of high temperature above 35°C maximum (see Table 4.) during the first month of the cotton growing season, and that these high temperatures are in turn correlated with poor growth of the cotton plant. This may partly explain the inability of the plant to recover and to produce a late crop, though so far no significant correlation has been established between these temperatures and yield. The sequence of the pests themselves may also prevent the recovery of the crop, for example in 1951/52 after its attack of blackarm cotton was afflicted by one of the heaviest whitefly attacks on record.

Late growth was discouraged by cold weather in December and the crop was finished off quickly by hot weather in February and March. (see Table 3 and 4).

The average yield of all main crop plots on the G.R.F. was 1.75 k.p.f. There is no doubt whatsoever that the heavy growth of weeds and delayed weeding mentioned above was mainly responsible for this. In particular the grass *Ischaemum brachyatherum* (lukh) was severe and persistent. In the Gezira this grass normally retains its inflorescence and seed within its leaf sheath, but in 1950 the inflorescence and consequently the seed were produced freely outside the leaf sheath, and resulted in a much wider and more effective dispersal of seed. Other weeds undoubtedly also reproduced themselves more effectively in 1950 and perennials such as seid (*Cyperus rotundus*) were also encouraged by the wet 1950 season. This build up together with the late germination and delayed hoeing made weeds a most important factor.

In view of an anticipated heavy jassid attack, and as the greater part of the Gezira was being sprayed, most plots on the G.R.F. were sprayed with D.D.T. in 1951. Significant responses to spraying were obtained in the Pest Control Experiments (see below). Part of the main crop was sprayed and Table 6 gives the yields from the main sprayed and unsprayed areas.

Table 6.

Yield of Seed Cotton (X1730A) from New Extension Main Crop.

Not sprayed (includes 1 plot Sakel)	0.805 k.p.f.
Partial Spraying (used for entomology expts.)	1.285 k.p.f.
Complete spraying (low volume)	2.690 k.p.f.

In spite of these figures it was considered that weeds (in particular *Ischaemum*) and blackarm by themselves could explain the lowest yields, as they were worse in the unsprayed plots. Blackarm had been fairly widespread in the previous season, though the remarkable late growth of the 1950/51 crop masked its effect, and the unsprayed area was in fact the nearest to the source of infection from the previous crop. The defoliation caused by blackarm probably left extra space for *Ischaemum* to develop.

All samples from the G.R.F. which were graded were of low grade, and small badly opened bolls were common. Weight of seed cotton per boll was below average and examination of a sample of bolls showed that this was due either to reduced weight per seed, to reduced number of seeds, or to both. Undoubtedly the factors contributing to the poor nutrition of the crop also affected boll weight and boll opening.

THE 1951/52 COMMERCIAL CROP.

The crop in the Gezira as a whole was subjected to the same adverse influences as that at the G.R.F. and in consequence the low yield of 3.10 k.p.f. (2.97 excluding the two new blocks) was obtained. There is no difficulty in finding an explanation for this poor yield, but it is not easy to apportion the right weight to all the factors concerned.

The overall yield estimated from the two rainfall factors and using the 40 block equation was 1.94 k.p.f. — much below the actual yield. During 1951 a preliminary estimate of increased yield of 0.69 k.p.f. for manuring and 0.83 k.p.f. for spraying were given by the Gezira Board, the areas manured and sprayed being 127,000 feddans and 205,000 feddans respectively. If the yield estimate is corrected by the addition of increases calculated from these figures (and a small response to fallow hoeing) we find that, as in 1949/50, this corrected estimate (3.074 k.p.f.) is practically the same as the actual yield. This is recorded only as a remarkable coincidence, as, apart from the statistical invalidity of the corrections, particularly that for increase from spraying, it is impossible to believe that the rainfall equation takes such accurate account of the miscellany of pests, diseases and other factors known to affect the 1951/52 crop.

In different parts of the Gezira adverse factors were more or less intense than at the G.R.F. Particularly in the south, post-sowing rains caused waterlogging as well as delayed weeding. Cotton had to be resown in waterlogged areas only to be ruined by flea beetle and thrips. Whitefly was everywhere very severe, and wilt, which was in places very severe, was thought to be associated with them. Blackarm was severe in many places and was kept going by a humid warm October. Leaf curl was more widespread than usual. These diseases were undoubtedly encouraged by the bad clean up following the immense 1950/51 crop. The lack of presowing rains also delayed the emergence of seedlings and ratoons till the new crop was actually growing, thus providing a source of infection which would normally have been disposed of before sowing.

Weather and other conditions were more normal in the north and the yield there was about average.

Grade was poor throughout the Gezira and small, poorly opened bolls were common.

EXPERIMENTAL RESULTS

In general experiments in 1951/52 gave the results normally expected.

Responses of cotton to nitrogenous fertilizers were much less than in 1950/51 though in some cases the relative responses were as high. Organic manuring gave good increases and the level of yields (including controls) in these plots was high. In this connection it is worth noting that L-F-C* and in some cases even D-F-C rotations gave better yields than F-F-C in 1951/52.

X1730A was markedly better than Sakel in nearly all experimental comparisons, though on the farm as a whole there was not much difference on account of the very poor yield of large main crop areas of X1730A.

Experimental results are given in more detail below. It should be remembered that most of the long term experiments were sprayed with D.D.T. against jassids for the first time in their history in 1951.

ROTATION EXPERIMENTS

1. *Continuous Cotton Demonstration.*

The overall yield of 0.97 k.p.f. was about one half of its 26 year average and 59 per cent. below its 1935/36 — 44/45 average.

A "look see" N.P.K. experiment was carried out in a small area of the plot in 1951/52, the same fertilizer rates as in the standard N.P.K. being applied. In this experiment 3N doubled the yield though this response was reduced when 4K was combined with 3N. The error was high and this interaction did not reach significance, but, averaged over all treatments, potash gave a significant reduction in yield of 0.38 k.p.f. Slight reductions from potash have occasionally been noted in the standard N.P.K. experiment, but these have never been significant. Further investigations into potash nutrition are being carried out in 1952/53.

* Throughout this report the following abbreviations are used :—

C = Cotton ; D = Dura ; L = Lubia ; F = Fallow

IN (P, K) = 40 rotls N per feddan (P₂ O₅ , K₂ O)

S.E. = Standard Error ; Sig. Diff. = Significant Difference.

C. of V. = Coefficient of Variation.

+ = Significant at P = .05 ; ++ at P = .01 ; +++ at P = .001.

2. Two Course Rotation Demonstration.

Yields of cotton were in the expected order : C-L, C-F, C-D. The overall yield was 41 per cent. below average, that of C-L being 55 per cent. and that of C-F only 27 per cent. below their averages. X1730A outyielded Sakel by 11 per cent. (average 7 per cent.) in this experiment.

The dura phase did relatively well in 1951/52 giving a yield of heads 77 per cent. above average. It should be noted that this dura crop followed the only 1950/51 cotton yield which was below average. The lubia phase yielded 20 per cent. below average. It started off well, but was severely damaged by whitefly in November.

3. Three Course Rotation Experiment.

In 1951/52 the yields of C-F-F, and C-D-D were 25 per cent. below normal, that of C-D-L 10 per cent. below and that of C-L-F only 3 per cent. below. C-L-F was as usual best, and C-D-L second best, being significantly higher than C-F-F.

In the dura phase yields of heads were above average and straw below average. D-C-D gave a significantly better yield than F-C-D. This has happened on several occasions and probably reflects the residual effect of the previous cotton crop. Lubia in the lubia phase started well but was damaged by pests. As in other plots lubia after dura was a failure, but after cotton it was good.

4. Combined Rotations Experiment.

Yields of cotton were all below average, those of the better rotations falling most. In 1951/52 C-F-D/L-F gave the highest yield significantly out-yielding C-F-F-F and C-D/L-F-F.

In the dura phase, yields of heads were above average, and unlike other dura plots, straw yields were slightly above average. Lubia yields were slightly above average, and this season there were significant differences between the yields of some rotations.

5. New Rotations Experiment.

Yields of cotton in this experiment were 20 per cent. to 50 per cent. below average. As in the three course rotation experiment F-F-C rotation did relatively much worse than the others. This is shown in Table 7.

Table 7.
Yields of Seed Cotton (X1730A and Sakel in New Rotation Experiment
(k.p.f.)

	Average 43/44-49/50	49/50	50/51	51/52
C-F-F	5.85	4.01	6.93	3.04
C-D-F	4.79	3.90	6.65	3.87
C-L (J)-F	6.54	4.88	9.30	5.03
C-L(S)-F	6.25	4.13	8.09	4.90
C-(D+L)-F	5.34	4.28	6.78	3.74
Mean	5.75	4.24	7.55	4.12

In the dura phase, yields of both heads and straw were low this being an area where *Striga* is severe. Yields of dura are always low in this experiment and this may explain why yields of cotton in the C-D-F rotation are relatively high. Dura following Sakel gave a significantly greater yield of both heads and straw than that following X1730A.

In the lubia phase, both July and September sown lubia promised well but the yield was reduced to below average by whitefly. Growth of December-sown lubia was very slow because of cold weather in December, but improved later as the weather got warmer.

6. Fodder Rotations Experiment.

In this experiment dura yields were about average for heads and below average for straw. Yields fell more or less in the usual order. All lubia yields were low in this experiment, only F-L and D-F-L rotations producing a real crop. Lubia immediately following dura was a complete failure as in previous years. Failures are attributed to cockchafer grubs and termites, and poor yields generally to whitefly. When this experiment starts on its second round in 1954/55 it is hoped to split the lubia plots for cockchafer and termite control treatments.

ORGANIC MANURING EXPERIMENTS

1. Farm Yard Manure Experiment.

The level of all yields in this experiment were very high when compared with most other 1951/52 yields. Some responses to the manurial treatments were significant but the yield of the control treatment was also high. Residual yields in the L-F-C- phase were very high. Table 8 gives the 1951/52 direct and residual yields.

Table 8.

Yields of Seed Cotton from Farmyard Manure Experiment
(k.p.f.)

Direct.						Residual.					
46/47	47/48	48/49	49/50	50/51	51/52	46/47	47/48	48/49	49/50	50/51	51/52
L	F	C	D	F	C	D	F	C	L	F	C
I	Ration fed Jan. 1950				5.15	(1)	Ration fed Jan/47				6.78
II	Ration fed Jan. 1951				4.99	(2)	Ration fed Jan/48				7.28
III	Ration+C. Cake (Jan/51)				5.77	(3)	Ration+C. Cake (Jan/48)				7.40
IV	Ration+C. Cake (Jan/50)				5.42	(4)	Ration+C. Cake (Jan/47)				7.70
V	Nil—Control				4.86	(5)	Nil—Control				6.72
Significance						Significance					
Sig. Diff. (P=0.05)						(N.S.)					
Mean of treatments I- <u>IV</u>						Mean of treatments (1)–(4)					
treatment <u>V</u>						treatment (5)					
Significance						(N.S.)					
Sig. Diff. (P=0.05) 0.39											

In view of the high yield of the control treatment it is not possible to attribute the high yields of this experiment to the manuring treatments, but it must be remembered that the rotation used in this experiment, D-F-C-L-F-C, is one which contributes organic matter, specially as the lubia (which follows cotton) is usually good. It has already been noted that the D-F-C and L-F-C rotations were relatively much superior to F-F-C in 1951/52, so that this experiment as a whole has benefited from its rotation.

In the dura phase there were slightly higher yields on the plots previously receiving manure, but these were not significant. The lubia crop was excellent and, though reduced by whitefly, it still gave a good yield of seed.

2. New Organic and Green Manure Experiment.

As in the Farm Yard Manure Experiment yields were relatively very high for the season. In this experiment one series of treatments are applied in a L-F-C- and the other in a F-F-C rotation. Table 9 gives the direct effects :—

Table 9.

Yield of Seed Cotton from New Organic and Green Manure Experiment
(direct effects)
(k.p.f.)

	46/47	47/48	48/49	{	49/50	50/51	51/52				
Rotations :	D	—	F		—	C	L	—	F	—	C
					F	—	F	—	C		

TREATMENT	Yield
(5) Lubia grazed by sheep folded Jan. 1950	7.87
(6) Lubia grazed by cattle (day only) Jan. 1950	6.63
(7) Lubia ploughed in and watered Jan. 1950	7.36
(8) Lubia cut and removed Jan. 1950	6.17
(1) Fallow—Fixed ration fed to sheep Jan. 1951	7.01
(2) Fallow—as (1)+(C. Cake fed to sheep Jan. 1951	6.80
(3) Fallow—as (1)+(C. Cake applied to land March 1951	6.46
(4) Fallow—Nil—No feeding or application	6.14
Significance	xx
Sig. Diff. (P=0.05)	0.92

Though the L-F-C rotation is superior to the F-F-C the yields of the latter do not support the suggestion made above that the high level of yields in the organic manure experiments was due to the rotation.

The residual effects in these rotations which occur in the D-F-C phase, showed no significant differences.

In the dura phase, yields of heads were about average and straw below average. Lubia yields were below average.

OBSERVATION PLOTS.

Old Observation Plot (II. 57).

The yield of plot 57 (unmodified) was 3.125 k.p.f. This is lower than usual relative to Gezira Scheme yields, but not to other Sakel yields on the G.R.F. See Table 10.

Table 10.

Yields of Plot 57 related to other yields

	Plot 57	Plot 16 and 17 (same variety etc.)	Total	Percent of P. 57	
			S.G.B. Area	Plot 16 and 17	Total S.G.B. Area
Av. 1935/36—44/45	7.51	—	4.21	—	57
Av. 1939/40—44/45	7.53	7.92	—	105	—
45/46	5.70	5.25	3.41	92	60
46/47	4.06	4.58	4.03	113	99
47/48	2.67	3.95	3.39	160	137
48/49	1.47	5.06	4.26	257	216
49/50	3.38	4.56	4.58	135	135
50/51	12.61	10.72	6.78	85	54
51/52	3.13	3.19	2.97*	102	95

Thus G.R.F. Sakel yields and not plot 57 yields were abnormally low in 1951/52. When comparing plot 57 with the Gezira yield it must be remembered that the northern Gezira which grows Sakel gave a comparatively good yield. Table 11 gives a rough assessment of this.

Table 11.

Yield of Plot 57 related to S.G.B. Crop yields

	P. 57	South	Centre	Mess.	W. Shair	North	Mean
Av. 1935/36- 44/45.	7.51 (100)	5.11 (68)	4.56 (61)	3.66 (49)	4.25 (57)	3.66 (49)*	4.25 (57)
1951/52	3.13 (100)	2.90 (93)	2.89 (92)	2.86 (91)	3.10 (99)	3.10 (99)	2.97 (95)

* Excluding 2 new blocks.

In 1951/52 part of plot 57 followed unhoed fallow (temporary modification). The yield from this part was 2.84 k.p.f. or practically equal to that of the normal hoed plot. In other experiments responses to hoeing were large in 1951/52. The small response in H. 57 may be associated with several factors *e.g.* the high level of nitrate in this plot or the over-riding effect of blackarm and leafcurl.

Observations in Plot 57:

These indicate that blackarm and leafcurl were both higher than usual and undoubtedly their combined effect reduced the yield considerably. The percentage of plant holes affected by blackarm in 1951/52 was 12.8 against 1.5 in the previous year. This percentage was by far the highest recorded in recent years. At the end of the season 88.5 per cent. of plant holes were infected with leafcurl — well above the average, but not as high as in some recent years of very poor yield. As has been shown previously low yield of seed cotton per boll is associated with leafcurl, and this was again apparent in 1951/52. The weight of seed cotton per boll was 1.81 gms. against 3.11 in the previous year and a normal weight of about 2.5 gms. Defoliation (on account of blackarm) was the highest in recent years — a loss of 23.7 main stem leaves per plant. The poor yield was undoubtedly due in considerable part to the joint effect of blackarm and leaf curl.

It must again be stressed that final observations show only half the picture. Study of the detailed observations shows that during 1950/51 early growth was satisfactory and in sharp contrast to that of 1951/52 and to that of the last season of poor July-August rains (1949/50). For example in 1949/50 there was an increase of 12.75 gms. dry matter per plant between August and October, in 1950/51 this figure was 31.62 and in 1951/52, 21.81. Normally it is well over 25 gms.

It has been found that the total dry matter at the end of October is correlated with spells of high temperatures (see Table 4) during the first fortnight of growth ($r = -0.6101++$). It will be noted that these spells were severe in 1949/50, and that differences in yielding potential are probably associated with this temperature growth correlation. This yield potential is modified to such an extent by pests and diseases that it appears to be only weakly correlated with final yield. However investigation of these correlations has not gone far enough to be assertive on this point. It is fairly certain that pests and diseases (particularly the latter) played the most important part in reducing the yield of plot 57 in 1951/52. Basic growth factors were not of major importance in the early stages, though low temperatures during the winter may have been important in preventing recovery from the pests and diseases (c.f. 1950/51 season).

Gezira Observation Plots.

The yields obtained in the Gezira Observation Plots in 1951/52 bear the usual relationship to those of the neighbouring commercial crop. (see Table 12).

Table 12.
Comparison of G.O.P. and Commercial Crop Yields
(k.p.f.)

Site	Variety	Mean	
		45/46—50/51	51/52
Turabi G.O.P.	Domains		
	Sakel	5.16 (100)	4.20 (100)
Turabi Block	„	3.48 (67)	2.69 (64)
Kab el Gidad Block ...	„	4.16 (81)	3.53 (84)
G.R.F. G.O.P.	X1730A	5.50 (100)	3.59 (100)
Barakat Block	X1730A	4.66 (85)	2.66 (74)
Hag Abdulla G.O.P. ...	X1730A	8.61 (100)	4.28 (100)
Hag Abdulla Block ...	X1730A	5.56 (65)	2.94 (69)
Abu Guta G.O.P.	X1730A	5.45 (100)	3.89 (100)
Abdel Magid Scheme ...	X1730A	3.91 (72)	2.42 (62)

A feature of the season was the relatively poor yields of Sakel types in all G.O.Ps. except Turabi. At Hag Abdulla, G.R.F. and Abu Guta, Massey's Selected Domains Sakel (M.S.D.S.) yielded significantly less than X1730A. This was in part due to the unusually heavy blackarm doing relatively more damage to Sakel types than to X1730A. These points are illustrated in Tables 13 and 14.

Table 13.
Yield of Massey's Selected Domains Sakel and X1730A at
Different Sites.
(k.p.f.)

Site	Mean 45/46—50/51		1951/52	
	M.S.D.S.	X1720A	M.S.D.S.	X1730A.
Turabi	5.33	—	4.38	—
G.R.F.	4.90	5.50	2.69	3.59
Hag Abdulla	7.08	8.61	2.00	4.28
Abu Guta	4.83	5.45	2.55	3.89

Table 14.

Average per cent Plants of M.S.D.S. infected with Blackarm in sample of 31/10.

Season	Turabi	G.R.F.	Hag Abdulla	Abu Guta.
1945/46	Nil	Nil	0.03	Nil
1946/47	Nil	2.65	20.1	Nil
1947/48	9.4	0.75	Nil	17.85
1948/49	Nil	1.40	Nil	Nil
1949/50	Nil	9.27	12.24	Nil
1950/51	0.4	28.0	Nil	99.24
1951/52	31.2	54.9	2.1	88.2

It is worth noting that in 1950/51 the G.O.Ps. which had a high percentage of blackarm outgrew the infection and yielded well. At Hag Abdulla in 1951/52, though blackarm was less severe, wilt attacked M.S.D.S. severely, and thrips were severe on both varieties. Whitefly, asal and wilt were recorded in greater or less degree in all G.O.Ps. and in Plot 57, the main damage being caused at Hag Abdulla and the G.R.F. Leafcurl was not as severe or as early as in plot 57 or as in some of the Gezira crop. An adequate explanation of the early incidence of leafcurl in plot 57 is still required.

In general the G.O.P. observations follow the same pattern as those of Plot 57. Associated with the pests and diseases, defoliation and leaf shedding were high. There was very poor late growth. Here again pests and diseases and non recovery from them appeared to be the main causes of poor yields.

FERTILIZER EXPERIMENTS.

1. *Types of Nitrogen Experiment.*

Responses to nitrogen were good in this experiment, 1N giving an increase of 1.36 k.p.f. (app. 35 per cent.) and 2N, 2.38 k.p.f. (app. 62 per cent.). There was no significant difference between the different types of nitrogen tried, but the response to applications 8 weeks before sowing was significantly less than that applied at sowing time or 6 weeks after. This is an unusual result which may be associated with the time of weed growth. A response of over 1 k.p.f. from hoeing the two fallows before cotton was obtained in this experiment.

2. *N.P.K. Experiment.*

The responses to nitrogen in this experiment were of the same order as in the Types of Nitrogen Experiment. A study of past yields of this experiment has been carried out and is discussed on p. 37. It will be seen there that an interesting correlation has been established between high rainfall and high response to nitrogen in this experiment.

Phosphate and potash had no significant effect on cotton, but the residual effect of phosphate gave a significant increase in the yield of lubia following cotton. Residual phosphate usually increases lubia yields, but the response is not often significant.

3. *Residual Nitrogen Experiment.*

The yields in this experiment fell in the expected order. As usual fertilizer applied to the fallow before cotton was equally as effective as that applied direct to the cotton.

In the direct application in the dura phase, 2N gave significantly greater yields than 1N and ammonium sulphate greater yields of heads, but not of straw, than cotton cake.

4. *Urea Spraying Experiment.*

In this experiment the effect of spraying urea alone and with D.D.T. was tried at the time of anti-jassid spraying. Urea was applied at the rate of 20 rotls N per feddan in 100 gals. spray. It did not increase yields significantly either alone or with D.D.T. It caused slight burning at the tips of the leaves, but this might have been prevented by inclusion of a spreader and wetter in the urea spray. In view of these results and the increased use of low volume spraying it would seem that inclusion of urea in anti-jassid sprays is not worth considering.

FALLOW HOEING EXPERIMENTS.

1. *Permanent Fallow Hoeing of Cotton Experiment.*

In this experiment there was a significant response to hoeing the 1950 fallow but not the 1949 fallow. Rainfall was high in 1950 but low in 1949 so results were as expected.

2. *Permanent Fallow Hoeing of Dura Experiment.*

In the parallel experiment with dura a significant increase followed the hoeing of the 1950 fallow but not the 1949 fallow.

3. *Influence of Fallow Weeding on Rotation Comparisons.*

Hoeing the fallow before cotton gave an average increase of 1.11 k.p.f. in this experiment, the response being greatest in the L-F-C rotation and least in the D-F-C. X1730A significantly outyielded Sakel and the L-F-C rotation was the best though not significantly better than (hoed) F-F-C.

In the dura and lubia phases differences following hoeing and non hoeing of the fallow before cotton were not significant.

4. *Effect on Dura of Fallow Hoeing, and Residual Fallow Hoeing and Nitrogen.*

This is the last phase of a short term experiment on the effect of manuring and hoeing in the rotation F-C-F-D; the fallows before cotton and dura being hoed and not hoed in all combinations, and manure and no manure treatments being applied to cotton. Hoeing of the fallow immediately before dura caused a 65 per cent. increase in yield of heads and there was a slight significant increase from the residual effect of manure (2N) applied to the previous cotton.

WATERING EXPERIMENTS.

1. *Sprinkler Experiment.*

A sprinkler was again used to simulate rainfall from July 1st. to August 14th. and the equivalent of 360 mm. of rain was applied in this period. Despite the very small amount of natural rain no increase in yield was obtained from sprinkling or from prewatering by furrow irrigation during the period. The yields obtained are given in Table 15.

Table 15.

Yields of Seed Cotton from Sprinkler Experiment
(k.p.f.)

Control (natural rainfall only)	4.99
Sprinkling (= 360 mm. rain)	4.92
Furrow irrigation (= 360 mm. rain)	3.17

These treatments were not replicated because of the practical difficulties involved in sprinkling, so that no statistical significance can be attached to the results. However this experiment has been repeated in one form or another often enough to make it probable that the direct effect of rain on the soil (*i.e.* sprinkling) is not a major factor in the July-August rain effect.

2. *Prolonged Watering Interval in October.*

The original purpose of this and a similar experiment carried out in 1950/51 was to see if grade could be improved by stopping October water. No effect on grade was found in either season, but the yields provide an interesting comparison between the two seasons — see Table 16.

Table 16.

Yield of Seed Cotton from October Water Interval Experiment.

(k.p.f.)

1950/51 Experiment				1951/52 Experiment			
Normal Watering	...	...	5.75	Normal Watering	...	...	5.12
2 Waterings stopped	...	...	5.42	1st. Oct. Watering stopped			3.95
3 Waterings stopped	...	...	4.47	2nd. Oct. Watering stopped			3.42
Significance	...	...	+	Significance	...	...	++
Sig. Diff.	...	...	0.85	Sig. Diff.	...	...	0.47
				2 Waterings stopped (belt)	...		2.92

In 1950/51 it was remarked that the check in growth due to water stoppage was compensated for by new growth late in the season. It will be seen that two and three water stops in 1950/51 are compared with only one and two in 1951/52. In 1951/52 even though the check was less severe (judged both by treatment and visual effect) there was no late growth to compensate for it. This is a neat demonstration of one of the main differences between the 1950/51 and 1951/52 seasons.

MISCELLANEOUS EXPERIMENTS.

Standard Pest Control Observation Plots.

As in previous years these were carried out at the G.R.F., Turabi and Abu Guta. It will be seen that in all cases spraying gave significant increases and at Turabi and Abu Guta two sprayings were significantly better than one. In this connection it must be remembered that the unsprayed plots provided a source of reinfestation which may not have been present in the scheme as a whole. Table 17 gives the yields.

Table 17.
Yields of Pest Control Experiments 1951/52.
(k.p.f.)

Treatment				Turabi	G.R.F.	Abu Guta
1.	No Spraying	...	...	3.27	2.98	2.53
2.	Sprayed once (Mid. Oct.)	...		3.85	3.73	2.75
3.	Sprayed twice	...	...	4.70	3.37	3.34*
Sig. Diff. between 1, 2 and 3				0.54	0.49	0.29
Sig. Diff. between 2 and 3				0.63	0.56	0.34

* This was sprayed 3 times.

Special Picking and Grading.

During the two previous seasons the grading of crop from different zones of individual plants showed only that later pickings were of lower grade, and it was decided to discontinue these special pickings in 1951/52. However it was apparent that, on account of pests and diseases, a single plot of cotton in 1951/52 contained a number of different kinds of plants and it was decided to pick these separately to see what contribution each type made to the grade of the plot as a whole. Good bolls, badly opened bolls (bollworm) and badly opened bolls (not bollworm) were also picked and graded separately. Plants with defoliation probably suffered from blackarm though this is not specified. Differences in grade showed up mainly in the first three picks. Results for these are summarised in Table 18, where Grade 1 is the best quality and Grade 7 the poorest.

Table 18.

Grades of different types of plant from the same plot, and
different types of boll from the same plants. —

Mean for 1st. 3 pickings.

	Good Bolls			Bad Bolls N.B.W.			Bad Bolls B.W.			Weighted Mean	
	% by wt.	Wt. of S.C. per boll (gms.)	Grade	% by wt.	Wt. of S.C. per boll (gms.)	Grade	% by wt.	Wt. of S.C. per boll (gms.)	Grade	Wt. of S.C. per boll (gms.)	Grade
Good Plants	85.6	2.13	3.3	11.6	1.09	6.6	2.8	1.24	6	1.98	3.8
Plants with Defoliation.	87.9	1.89	4.0	7.5	0.86	7.0	4.6	1.56	6	1.80	4.3
Plants with Wilt ...	73.6	1.42	5.0	21.6	0.89	6.3	4.8	1.08	6.3	1.29	5.3
Plants with Leaf Curl	84.7	1.97	4.3	10.7	1.08	6.5	4.5	1.23	6	1.84	4.7

It is obvious from the above that in a bulk samples from a single plot in 1951/52 grade would be reduced by admixture of badly opened bolls and even by good bolls from diseased plants. Above average disease in 1951/52 would thus partly explain poor grades, but the fact remains that even good bolls from healthy plants were not good grade.

III. Crops other than Cotton.

by H. Ferguson

DURA

Experimental work on dura was again mainly confined to that carried out in rotation and long term experiments. These have been reported in part II of this report.

Because of the very low rainfall during July and August 1951 watering of dura was difficult and resulted in poor stand. Further damage was caused by grasshoppers so that the crop was generally difficult to establish. Much resowing had to be done, but, even so, the stand in some plots was patchy. Growth was satisfactory during the later part of the season. Infestation by buda (*Striga hermonthea*) and the common pests was about average and none of these caused serious loss. Yields were generally below average mainly as a result of poor stand and late establishment. Where these were satisfactory, good average yields were obtained. In all cases straw yields were much below those of 1950/51, the latter being a season very favourable to vegetative growth.

ALTERNATIVE CASH CROPS.

Because of shortage of land and staff, work on alternative crops at the Gezira Research Farm was again confined to a few small observation plots. Observations on the effect of crop sequence and of manuring were made on castor, Deccan hemp, sunflower, groundnuts, safflower and wheat, with cotton and dura included for comparison. The 1951/52 observations largely confirmed those of the previous season. Establishment of crops after dura was found to be very difficult in 1951/52. Variety trials for groundnuts and sunflower and variety observations on castor were carried out. A date of sowing and manuring observation was made on jute and Deccan hemp.

The 1951/52 season was a much worse one for many of the crops tried than was that of 1950/51. Most of these crops have to be sown during July so that early watering and establishment were very difficult and much resowing was required. The 1951/52 winter was cool and this favoured winter crops such as wheat and safflower.

A precis of the work done on other crops was given in the 1950/51 report and so only crops and observations of special interest are recorded in this season's report. The Gezira Board carried out trials of sunflower, Deccan hemp, castor and safflower on a tenancy scale at Wad el Nau. Growth of all these crops was successful particularly when it is remembered that the season was a bad one. These large scale trials indicated further lines of investigation and gave useful information on the economics of growing these crops.

Castor.

The 1951/52 observations again showed that castor responded markedly to nitrogenous fertilizers even at spacings of 150 cm. used in this season. Growth was again better after legumes than after non-legumes. A certain amount of leaf shedding due to pests and diseases (not yet fully identified) took place at the G.R.F. Grasshoppers caused some damage. Both the G.R.F. and Wad el Nau experiments stressed the need for a castor variety which would mature on free period water. ECR 1167 (Gunson's variety) which was under observation matured in less than three months, and further introductions and observations will be carried out on varieties of this kind. Before growing castor on a big scale in the Gezira a good quick maturing variety must be obtained and methods of mechanical threshing and possibly harvesting developed.

Sunflower.

In the variety trial Striped Gray (ECR 616) Saratov (ECR 844) and Saratov (ECR 845) were amongst the best with yields of approximately 900 rotls seed per feddan. Establishment had been difficult and generally stand was not good and heads were small. No variety was good. Damage was caused to young leaves by the blister beetle *Epicauta aethiops*, and to the heads by American bollworm.

At Wad el Nau nearly all seeds were unfilled. The variety grown there was Striped Gray, but at the Research Farm it was found to have 99 per cent. filled seed.

Sowings after August yielded practically nothing, flowering tending to take place very early during the short days. Table 20 shows the heights of Deccan hemp and jute at the time of flowering.

Table 20.
Heights of Deccan Hemp and Jute at Flowering Time
(Mean height of crop in feet)

Sowing Date					Deccan Hemp		Jute	
					N	ON	N	ON
July	...	...	...	...	6½	5½	5½	4½
August	...	...	...	...	4	3	4	3
September	...	...	...	...	2½	2	½	½
October	...	...	...	...	2½	2	½	½
November	...	...	...	...	4	4	½	½
December	...	...	...	...	4½	4½	½	½

Even the best growth and yield of Deccan hemp was poor compared with 1950/51 when a 9 ft. tall crop was obtained. Height and yield are also much less than in Equatoria, confirming the conviction that bast fibres should be grown in more humid, cloudier regions.

Flea beetles, jassids and whitefly were present on Deccan hemp and must have done some damage. A disease similar to crown gall was recorded on some plots where Deccan hemp had been grown in the previous season.

Retting of Deccan hemp did not cause undue difficulty at the G.R.F. but proved a tedious and tiresome job at Wad el Nau where 40 feddans were grown. Difficulty was also encountered with later batches presumably because bacterial activity was reduced by over stagnation of the water. It was found at the G.R.F. that the hand stripping of green ribbons was much more difficult in the Gezira than in Equatoria. Ribbons did not come off completely or clean, specially if any time elapsed between cutting and ribboning. The proportion of fibre to stems was rather less than in Equatoria, presumably because they were shorter and more branched. Retting or ribboning are the main problems requiring to be solved before Deccan hemp can be grown on a large scale.

Jute (Corchorus olitorius) (ECR 576).

Jute grew badly, as it usually does at the Gezira Research Farm. Good jute was grown on river silt at the irrigation garden. At the G.R.F. the first sowings of jute failed to germinate on account of dry weather and poor watering. Growth improved when cool rainy weather arrived. Some damage was caused by flea beetle. Table 21 gives yields from samples taken from the jute observation plots. Even the best yield was not high.

Table 21.
Yield of Jute (ECR 576)
(rotls clean fibre per feddan)

Sowing Date	Nitrogen	No Nitrogen
July (Irrigation Garden)	—	482
July (G.R.F.)	276	150
August (G.R.F.)	89	47

From the fibre point of view sowings from September onwards completely failed. Retting time varied apparently with water temperature.

The tall selected variety from Equatoria (ECR 576) was again taller than any others grown. A small amount of indigenous jute from the central rainlands was grown, but germination was again poor.

Sunn Hemp.

Sunn hemp was badly damaged by blister beetles resulting in a very poor stand. Growth was fair. A sample of sunn hemp fibre submitted to a firm of paper manufacturers received an excellent report.

Wheat.

The 1951/52 winter season was cool for a long period and this favoured the wheat crop, which grew extremely well at the Gezira Research Farm and Abu Guta. As in 1950/51 wheat responded to applications of N fertilizer and grew better after summer than after winter crops.

Rice.

Small plots of upland rice and swamp rice were tried in 1951/52. Swamp rice with and without nitrogenous manure, and with complete and partial flooding was in all cases poor. The crop was difficult to establish and practically no growth took place during the hot weather. Upland rice grew and yielded badly, nearly all seeds being empty.

Sugar Cane.

A small plot of sugar cane was grown. It was difficult to establish because of termites. Growth at all seasons was poor. After 9 months it had still not shot, and its growth was severely affected by the hot weather in May and June despite weekly watering. Termite damage also increased during this period.

Other Cereals and Sugar Crops.

Barley grew well in propagation plots during the winter. Maize sown in July was as usual poor, but sown in October it was fairly satisfactory. Sweet sorghums again grew reasonably well.

FODDER CROPS.

Experiments were carried out on lubia and observations were made on a number of other fodder crops. Only crops which had been successful in previous seasons and were of special interest were tried in 1951/52. The 1951/52 season was extremely dry, similar to 1949/50 and in direct contrast to 1950/51. Establishment of a number of crops was difficult particularly after dura, but *Clitoria*, phillipesara (*Phaseolus trilobus*), and *Leucaena* all germinated and grew well, again confirming their suitability for the range of conditions found in the Gezira. A number of leaf spots were noted on leguminous fodder crops in 1951/52. These were due mainly to species of *Aschochyta*, *Phyllosticta* and *Macrophomina*.

Lubia (*Dolichos lablab*).

Most experimental lubia is an integral part of other larger experiments and has been reported elsewhere. In 1951/52 an experiment was carried out in cooperation with the Entomology Section on seed and soil treatments to control cockchafer grubs.

The 1951/52 season started off satisfactorily for July-sown lubia, there being little rain and little bacterial disease. Rains later caused spread of bacterial disease and the lubia suffered severe damage from thrips and whitefly. Some damage was also caused by the chrysomelid beetle, *Luperodes quaternus*.

Lubia following dura, whether sown in July or September, was badly damaged by cockchafer grubs, both stand and growth being extremely poor. This condition was not improved by different methods of disposing of dura stubble, but considerable success was achieved by treating soil or seed with different formulations of BHC. In the experiment mentioned above treated plots made almost full stands and the best treatment (Agrocide 2 at 10 lbs per feddan) gave a yield of 8137 r.p.f. fresh lubia against 1833 untreated. Maincrop lubia treated in the same way was successful.

The benefit of mixing lubia with other legumes which are resistant to bacterial disease and other pests was again demonstrated in 1951/52. Table 22 gives weighings from sample areas of mixtures and pure fodder legumes.

Table 22.
Yield of Fodders.
Fresh Weight r.p.f.

Fodder	Yield
Lubia alone	11,144
Lubia plus phillipesara	23,230
Lubia plus Clitoria	17,137
Clitoria alone	16,436
Leucaena (medium)	4,938 (inc. some wood)
Leucaena (good)	8,508 (" " ")

It must be stressed that the above does not complete the picture, as the aftermath has not been measured. That of lubia plus *Clitoria* was much greater than lubia plus phillipesara.

Velvet Bean.

Velvet bean was generally not very successful in 1951/52. It was severely attacked by blister beetles at the beginning of the season and stand and growth were severely reduced. Velvet bean is therefore not reliable in all seasons.

Kordofan Pea (Clitoria ternatea).

This crop grew extremely well in 1951/52 and further observations have shown it to be one of the most promising legume crops in the Gezira. Its value in mixtures is mentioned above. It regenerates most vigorously from the stumps after cutting or grazing. It thus produces heavy aftermath if watered. Following six dry months it produced a 100 per cent. cover from the stumps after about 50 mm. of rain. It therefore holds great promise as a useful leguminous competitor for fallow weeds. Unlike phillipesara and most other legumes, September-sown *Clitoria* grew actively and produced a reasonable bulk of green fodder.

Clitoria suffered from a stem rot (not yet identified), but this appeared after the plant should have been cut, and should not be important in practice.

Phillipesara (Phaseolus trilobus).

This crop was very successful in 1951/52 and is now well established as a vigorous fodder crop suitable for the full range of Gezira seasons. Scattering phillipesara seed was found to be less satisfactory than sowing in holes where land had to be weeded. In the early period of growth (July, August, September) phillipesara is very vigorous and tends to suppress all other legumes and to compete with grasses.

For the first time a leafspot due to *Aschochyta phaseolorum* was recorded. This was not widespread.

Leucaena glauca.

A laboratory trial of methods of seed treatment for this crop was conducted in 1951 and it was found that full and rapid germination could be obtained by soaking the seed for 5 to 15 minutes in 50 per cent. sulphuric acid. A trial plot was sown with treated seed and established a full stand. Yields of green fodder from this plot are given in Table 22 above. Cattle grazed this crop greedily but sheep with reserve, except when hungry. Observations this season confirm those of last and indicate the special usefulness of this crop as a source of firewood as well as fodder.

Other Legumes.

Phaseolus lathyroides was again successful in 1951/52, but its tendency to shatter its pods reduces its practical value. The smooth variety of cluster bean (*Cyamopsis psoraloides*) was multiplied up. A number of other legumes were grown in small plots but produced nothing noteworthy.

Grasses.

Sudan grass (*Sorghum sudanense*), anis (*S. purpureo-sericeum*), *Rottboellia exaltata* and *Brachiaria obtusiflora* all grew extremely well. The first three were tried in mixtures with legumes and in all cases suppressed the growth of the legumes. The legumes remained alive under the grasses and would have been encouraged had the grasses been cut early for hay.

Other Fodders.

A small plot of marrowstem kale was sown as a winter crop, but did not grow very well.

IV. Plant Physiology (Nutrition)

by H. D. FOWLER

A. VARIATIONS IN PHOSPHORUS CONTENT OF ROOTS, STEMS, AND LEAVES OF COTTON 1950/51.

These experiments were of a preliminary nature for the study of the uptake of phosphorus in cotton for reasons which will be discussed later. The chromatographic method was investigated pending the arrival of a Hilger Absorptiometer but was abandoned in favour of the standard colorimetric method when its possible usefulness had been demonstrated.

In the 1950/51 season soils from the NPK plots (38 S, 23 S, and 69 S) had been collected separately in pots, and cotton grown under treatments as follows :—

1. Control
2. N — 1 gm. ammonium sulphate per pot
3. 3N — 3 gm. „ „ „ „
4. P — 6 gm. superphosphate per pot
5. N + P
6. 3N + P

3 replicates of each treatment were set up. After 8 weeks the dry weight of leaves, stems and roots were taken and samples of mixed replicates from treatments 1., 4. and 6. kept for phosphorus estimations.

The oven-dried ground material was extracted with 2 per cent. acetic acid; this extractant was chosen because apparatus was not available for total phosphorus determinations and there is some evidence that an acetic acid extract reflects more accurately the nutrient status of a crop than total phosphorus. 1.0 gm. is placed in a 50 ml. Erlenmeyer flask and 25 ml. of 2 per cent. (V/V) acetic acid added. The mixture is shaken for 3 half minute periods over a 5 minute period, using a rubber stopper. It is then immediately filtered and the extract used for determinations (1).

Chromatographic method of phosphorus determinations.

The method is described in the Annual Report 1950/51. No further work was done to determine the exact relationship between stain length and phosphorus concentration on chromatograms and it was assumed that the stain length itself would give a fairly accurate measure of concentration.

2 ml. of the extract, prepared as above, were mixed with 2 ml. of 0.02 M. disodium hydrogen phosphate and used for spotting the papers. In each chromatogram duplicate spots of each treatment were run and the accurate stain length taken. The last paper received the same volume (3 ml.) of a pure solution of 0.02 M. disodium hydrogen phosphate. After spraying, half the measured stain length of the latter was subtracted from the stain length of each of the other results and it was assumed that the remainder was to be attributed to the phosphorus originally present. For example :—

	Stain length in mm.
Paper 1. Control	18.8
2. P	18.0
3. NP	17.0
4. Control	17.8
5. P	—
6. NP	15.0
7. 0.02 M. Na ₂ HPO ₄	21.5

Stain length due to added phosphate solution is one half of stain length of paper 7. = $21.5 = 10.75$ mm. After averaging, the duplicate results

2
—
due to phosphorus originally present will be

Control :	$18.3 - 10.75 = 7.55$
P	$18.0 - 10.75 = 7.25$
NP	$16.0 - 10.75 = 5.25$

If stain length is directly proportional to phosphorus concentration these figures will then be a measure of phosphorus present. In some cases, two chromatograms bearing triplicate spots have been run and the stain lengths then reduced to a common basis. The correlation coefficient between chromatographic and colorimetric results computed from the pooled variation within series is as high as 0.79, which is remarkable when it is considered that two large assumptions have been made.

Colorimetric method.

2.0 ml. of the extract prepared as above, but using 0.1 gm. instead of 1.0 gm., are pipetted into a 100 ml. beaker and 3 drops of 30 per cent. hydrogen peroxide added to destroy other organic reducing agents. The solution is dehydrated on the water bath and heated for half an hour after dryness to remove all trace of hydrogen peroxide. When cool, 95 ml. of distilled water are added, 4 ml. of standard ammonium molybdate in sulphuric acid solution and 10 drops of standard stannous chloride solution. Colour formation is measured 8 minutes after the last addition on a Hilger Absorptiometer and compared immediately against a standard phosphate solution,

Results.

The results are not of sufficient importance to be given in detail. The D. W. yields are not obviously related to the phosphorus content either in leaf, stem or root, although, in the latter, where the phosphorus content has fallen under superphosphate treatment the yield has also fallen. Except in two cases leaves, stems and roots all show a somewhat lower phosphorus content under nitrogen manuring than when non-manured.

B. REVIEW OF THE NPK EXPERIMENT.

A publication on the uptake and effects of superphosphate fertilizer on the cotton plant at the Gezira Research Farm is being prepared, which will incorporate the results of the NPK Experiment and others designed to amplify it.

In this and succeeding reports, therefore, only the major results will be described.

1. Yields 1941-51

The layout of the experiment has already been described in previous reports. One of the complicating factors in the consideration of the results is the fact that until the season 1945-46 the rotation was cotton-dura-fallow, which was then changed in the following season to cotton-lubia-fallow because the rotation was considered to be very exhausting on the limited nitrogen supplies. The effect on cotton therefore became apparent from the 1948-49 season onwards. In this report, also, the yield data of the influences of phosphate manuring with nitrogen are considered in the absence of potash only.

The average percentage increases in yield with phosphate application are given in Table 23, both for the total of 10 years and also for the separate periods under the dura and lubia rotations.

Table 23.
Percentage Increase in Yield from Phosphate

					%		
Period					ON	1½N	3N
1941/42 to 1950/51	...	...	...	...	6.6	2.8	4.1
1941/42 to 1947/48 (dura rotn.)	...	...			5.9	1.5	2.8
1948/49 to 1950/51 (lubia rotn.)	...	...			7.9	5.5	6.9

The lowest percentage increases are those at the $1\frac{1}{2}$ N level and, although it is not justifiable to compare the seven years of the dura rotation with the three of the lubia, yet it does appear that the additional nitrogen supplied in the latter rotation has played its part in conjunction with the phosphate fertilizer to increase the yield. This is not however borne out by the statistical analysis below.

Yields in relation to nitrogen application and rainfall.

The yield data without added phosphate reveal that nitrogen applications always produce an increase in yield with, however, marked seasonal divergences. Table 24 shows the yield increases between the medium ($1\frac{1}{2}$ N) and high level (3N) of nitrogen applications respectively, together with the total annual rainfall.

Table 24.
Variation in yield between different levels
of nitrogen application
(k.p.f.)

Levels of N.	SEASON									
	41/42	42/43	43/44	44/45	45/46	46/47	47/48	48/49	49/50	50/51
$1\frac{1}{2}$ N-ON	1.02	2.09	1.31	2.03	1.31	1.95	0.82	1.37	1.05	2.15
3N-ON	2.08	2.17	2.06	3.06	1.93	2.64	0.87	1.50	1.12	3.78
Annual rainfall mms.	278.9	395.7	316.3	476.9	247.1	420.9	250.3	439.3	247.4	404.5

Statistical examination of these results reveals that there is a close correlation between total annual rainfall and the yield difference ($1\frac{1}{2}$ N-ON). The within-plot correlation coefficient is $r = 0.84$ which is significant at the $P = 0.01$ level. However, the coefficient between total annual rainfall and the yield difference (3N-ON) is lower ($r = 0.61$) and is not even significant at the $P = 0.05$ level. Nitrogen fertilizer appears to work more efficiently in a year of high rainfall.

Yield in relation to phosphate application and rainfall.

The influence of phosphate fertilizer alone and in conjunction with nitrogen is not so obviously related to any climatic factor as is the case with nitrogen alone. Increased and decreased yields on application of phosphate occur most frequently at the medium level of nitrogen applied and it might have been thought that, in view of the correlation of yield-increase with rainfall at this level of nitrogen, some correlation would have existed between yield increase with phosphate, nitrogen and rainfall. The results of the statistical analysis below do not, however, lend any support to this view.

Results of statistical analysis of the main effect of phosphate.

Season 1944/45 was excluded from the combined analysis as the data could not be found. The influence of potash fertilizer was also omitted, only the OK plots being considered in the calculations. The main effect of phosphate was significant at the $P = 0.01$ level and mean yields over 9 seasons were :—

	k.p.f.
0P	6.39
2P	6.66

The interaction of main effect of phosphate with seasons was not significant, neither was the interaction of nitrogen with phosphate (averaging over all seasons). The interaction of nitrogen, phosphate and seasons also showed not the slightest suggestion of a real effect.

2. Phosphorus leaf contents: Seasons 1950/51 and 1951/52.

It has been claimed by certain workers of whom the chief exponent is Thomas (2) that the relation between the development and yield of a plant and its nutrition (determined by composition of its leaves) is more direct than exists between its development and yield and the quantity of fertilizer applied. The method is to use the composition of suitably selected leaves, namely those of the same physiological age, as the basis of comparison and to refer all experimental results to the dry weight of the leaf. It is claimed that the composition of leaves of the same physiological age from plants of a given species and variety growing on a relatively homogeneous soil and receiving different fertilizer treatments reflect these differences in the sense that, whenever a fertilizer element is effective, (as determined by the response of the plant to the application of that element), the response is always associated with an increase of that element in the dried foliage. An element may be readily absorbed and assimilated, however, and yet may actually diminish yield because its application may interfere with the absorption of another element, and quantitative relationships with other elements present must also be considered.

The two factors which appeared of interest in the results obtained were the time of uptake of phosphorus and the quantity of phosphorus taken up (referred to dry weight) in relation to yield.

The most obvious feature both in 1950/51 and 1951/52 was the relatively very large uptake of phosphorus very early in the life cycle, so that the first few weeks appear critical for the phosphorus nutrition of the plant, and may in some cases determine the final yield.

Both time and quantity of phosphorus-uptake are important as is well illustrated by determining the correlation coefficient for the treatment yields and the corresponding nutritive indices † at different dates from sowing in the 1951/52 season. These are shown in Table 25.

† The nutritive index for phosphorus, also called here the phosphate index (Sp) is the number of mgm.-atoms per 100 gm. dry weight. (3)

Table 25.
Correlation of Yield and Nutritive Index (Sp) at different
dates from sowing.

No. Days from Sowing.	Correlation Coefficient
32	+ 0.682 *
53	+ 0.039
67	— 0.362
81	— 0.843 **
95	— 0.765
109	— 0.552 *
123	— 0.540
137	— 0.617 *
151	— 0.444
165	— 0.267
179	— 0.505

At 32 days from sowing the phosphate index is positively correlated with the final yield, and the correlation is nearly significant at the 1 per cent level. At 81 days, however, the final yield is highly correlated negatively with the phosphate index, indicating perhaps that there has been a movement of phosphorus away to the flower and developing boll. It is at least suggestive that the relationship changes from positive to negative about the 53rd day, and flowering is considered to commence about 50 days from sowing.

If this correlation appeared in all seasons it would be strong evidence that phosphate is always a controlling factor, and therefore presumably lacking in the soil, but this is not so, and the 1950/51 results (although not taken for leaves of the same physiological age), together with certain results obtained subsequently, show no correlation between treatment yields and phosphate index. Seasonal changes are thought to be operative in these effects.

It will be realized, however, that leaf phosphorus content will not necessarily be related to the total phosphorus content of the plant. The emphasis in foliar diagnosis is on the leaf as giving the nutritional index irrespective of the fact that nutrients are passing both in and out of the leaf and the mineral content in other organs is changing. It has been assumed in this work that the leaf phosphorus level is a measure of the total phosphorus uptake, and general comparison of the average nutritive indices in the first 4 weeks from sowing show quite clearly that higher phosphate levels are reflected in higher yields.

A point which has been overlooked in these analyses is the estimation of leaf phosphorus from earlier in the life cycle, possibly even cotyledonary phosphate content.

* Significant at $P = 0.05$

** Significant at $P = 0.01$

C. PLOT 52 — N. P. EXPERIMENT.

This experiment was exploratory and designed to study the development of the cotton plant in relation to fertilizer treatments with nitrogen and phosphate alone and in combination, on soils treated with gypsum and untreated, the plants being both shaded and unshaded. It was hoped to obtain information from these treatments as to the possible effect of phosphorus and nitrogen fertilizers in the Tokar Experiment (p. 46). The treatments were specially chosen to resemble Tokar conditions. Gypsum, a form of calcium sulphate, has been used in experiments at the G.R.F. since 1927 for soil improvement. It was used here to make the soil more permeable to water thus corresponding more closely, it was hoped, to Tokar soil structure.

The layout of the experiment occupied two angaias on Plot 52. One half of each angaia was shaded and 3 ridges were allotted for each of the treatments; control, 4P, (4N + 4P) and 4N on soils both with and without gypsum treatment. 4N = 160 r.p.f. nitrogen as sulphate of ammonia; 4P = 160 r.p.f. P_2O_5 as superphosphate; Gypsum at 2 tons per feddan. Cotton variety X1730A was used.

Summary of developmental details.

The developmental details for each of the fertilizer treatments are summarised in Tables 26 and 27. The individual plant is used as the unit throughout.

Table 26.

Treatment	Growth Rate (Ht) Average cm week		Node Forma- tion Av/week		Defoliation Av. No. leaves /week		Flower Pro- duction Av/week.	
	Open	Shaded	Open	Shaded	Open	Shaded	Open	Shaded
<i>No Gypsum.</i>								
Control ...	2.4	3.9	0.7	0.9	1.1	1.2	2.7	1.1
4P ...	1.6	3.5	0.5	0.8	1.1	1.1	2.3	1.0
(4N + 4P)	2.8	4.1	0.9	1.1	1.0	0.8	3.1	0.9
4N ...	2.9	4.3	1.0	1.1	1.0	0.7	2.3	1.0
<i>Gypsum Treated.</i>								
Control ...	1.8	4.1	0.4	1.0	1.0	1.0	1.9	0.6
4P ...	1.7	3.1	0.3	1.0	1.1	0.7	2.5	0.4
(4N + 4P) ...	3.3	4.8	0.9	1.0	1.0	0.8	4.3	0.4
4N ...	3.1	4.6	0.9	1.2	1.2	1.1	2.3	0.2

All results averaged per plant.

Growth Rate.

The growth rate (height) is much greater in the shade than in the open but phosphate treatment alone results in a smaller plant, especially when unshaded. This effect of phosphate is apparent even when combined with nitrogen except in the presence of gypsum where combined nitrogen and phosphate treatments produce a greater increase. Gypsum appears to favour treatments in which nitrogen is present.

Node formation.

As with growth-rate phosphate treatment alone tends to decrease node formation which is more marked in the open. Nitrogen treatments either alone or with phosphate tend to produce increased nodes, again more marked in the open, but present whether gypsum treatment has been applied or not.

Defoliation.

Defoliation seems to follow a general pattern through all treatments, being somewhat greater in the open than in the shade.

Seed Weight and Lint.

Under light, nitrogen treatment produces an increase in seed weight which is not obviously different whether phosphate is present or not and is independent of gypsum treatment. Phosphate alone produces little effect. Lint weight seems to be greater under nitrogen treatment at the second picking on 27/1 but not noticeably different at the third, except under gypsum where the third picking gives the biggest difference and the second picking only slight. At the first picking, only treatments without nitrogen had mature bolls, both in the presence and absence of gypsum. Under shade, nitrogen treatments both with and without phosphate produced no bolls at this picking and there were no obvious differences between the other treatments.

Flower Production and Boll Shedding.

Nitrogen with phosphorus treatment caused increased flower production when unshaded but this decreased slightly when shaded. Nitrogen or phosphorus alone appear to have little effect, possibly even depressing flower production slightly. Under gypsum treatment shading decreases flower production but phosphorus has a slightly beneficial effect in the open which is strikingly augmented when combined with nitrogen.

Table 27.

Percentage Boll Shedding (not due to bollworm damage)

	Control	4P	4N + 4P	4N
No Gypsum. Unshaded... ..	3.0	3.8	3.6	7.2
No Gypsum. Shaded	13.9	8.7	14.1	14.7
Gypsum. Unshaded	5.0	5.2	3.6	4.9
Gypsum. Shaded	22.8	33.8	55.2	85.7

Table 27 has been compiled by taking the total flower production between 21st. October (the beginning of flower production) and 14th. January and calculating the percentage shed between those two dates. A more strict comparison could be made between the flower production at a certain time and the boll shedding 60 days later (the average period of maturation) but the former method is sufficiently accurate to show any obvious differences.

Shedding under shaded conditions is obviously much greater, but is reduced (except with gypsum) by the presence of phosphate alone. The most noteworthy feature, however, is the heavy shedding in the open with nitrogen alone, which is twice as great for the 4N treatment as for (4N + 4P). Even in the shade and under treatment with gypsum it is in all cases greater. Shedding in the early part of the season followed almost the same course for all treatments but nitrogen produced its maximum effect late.

Conclusions.

The tentative conclusions to be drawn from this exploratory experiment are, that nitrogen and phosphate treatment together result in increased flower production under light which is not brought about by either separately. Under shaded conditions differences in flower production are small. Nitrogen alone produces heavy boll shedding in the light and increases boll shedding under most conditions, while phosphate reduces boll shedding. In a soil rich in nitrogen and deficient in phosphate there will thus be a tendency to heavy boll shedding.

Phosphate leaf contents.

As with the NPK experiment, the uptake of phosphate is by no means uniform throughout the season and there appear to be a number of occasions when phosphate is taken up. In the open the average leaf content from October to January is higher for leaves unmanured with nitrogen, being 151 ppm. and 159 ppm. for control and 4P treatments respectively as compared with 121 and 113 ppm. for (4N + 4P) and 4N. The shaded plants do not show such clear differences.

Increases and decreases in leaf phosphorus content have been compared with increases and decreases in the flowering rate but there is no exact connection between the two; sometimes an increase in leaf phosphate is associated with a decrease in flowering rate, sometimes the reverse.

D. PLOT 52. SEED SOAKING EXPERIMENT.

In the Annual Report for 1950/51 are described the results of some pot experiments with cotton seed soaked in solutions of sodium and ammonium nitrates and phosphates. They appeared to indicate that sodium salts have a greater effect in producing increases in dry weight, especially on root development, and that prolonged soaking (4 hours compared with 2 hours) reduces the effect with sodium salts but increases it with ammonium salts.

One angaia was used on Plot 52 for the experiment, half of the area being shaded, the other half open. There were eight treatments, unreplicated, the seeds (of X1730A variety) being soaked for 4 hours and spread out to dry before planting. The strengths of solutions used were as follows :—

- F. Sodium nitrate. 85 gms./litre
- G. Ammonium phosphate $(\text{NH}_4)_2 \text{HPO}_4$. — 115 gms./litre
- H. Sodium phosphate $(\text{Na}_2 \text{HPO}_4)$. 142 gms./litre
- I. Ammonium nitrate. 80 gms./litre
- J. Sodium nitrate, 85 gms. + Sodium phosphate, 142 gms./litre
- K. Ammonium nitrate, 80 gms. + Ammonium phosphate, 115 gms./litre
- L. Sodium nitrate, 85 gms. + Ammonium phosphate, 115 gms./litre
- M. Ammonium nitrate, 80 gms. + Sodium phosphate, 142 gms./litre

Developmental Data.

The developmental data are summarised in Table 28.

Table 28.

Treatment	Av. Height increase cms./week		Av. Nodes/ Week		Defoliation/ Week No. of leaves		Av. Flowers/ Week	
	Open	Shaded	Open	Shaded	Open	Shaded	Open	Shaded
F Sodium nitrate ...	1.7	3.9	0.5	1.1	1.1	0.9	1.8	0.5
G Ammonium nitrate ...	2.3	4.5	0.6	1.5	1.1	0.9	2.2	0.4
H Sodium phosphate ...	2.7	5.7	0.7	1.4	1.1	0.9	2.4	0.5
I Ammonium phosphate ...	3.0	4.5	0.7	1.0	1.2	1.0	2.5	0.8
J Sodium nitrate + Sodium phosphate ...	2.8	4.9	0.8	1.2	1.2	1.0	2.9	0.8
K Ammonium nitrate + Ammonium phosphate ...	2.5	5.4	0.7	1.2	1.1	0.8	3.4	0.7
L Sodium nitrate + Ammonium phosphate ...	2.7	5.7	0.7	1.1	1.3	0.7	3.5	0.7
M Ammonium nitrate + Sodium phosphate ...	2.8	7.2	0.8	1.3	1.4	1.0	4.3	0.5

For control conditions these results may be compared with Table 26.

Growth rate.

Although sodium nitrate alone appears to have less effect than the other treatments, if all three treatments containing sodium alone are compared with those containing ammonium alone, increases both in the open and shade are comparable. The larger values in treatment M over treatment L may be due to additional nitrogen but this is not borne out by comparisons with other treatments.

Node Formation.

Shows little difference between treatments.

Defoliation.

Appears to be very constant throughout all treatments, but somewhat higher in treatment M.

Flower Production.

Although under shade flower production is very uniform, the average flower production in the open is slightly greater with all ammonium treatments than sodium. In all cases it is higher in treatments containing (N + P) than with either one alone.

Seed and Lint Weight.

Table 29 gives the weight of lint per boll and the weight of seed per boll averaged for three samplings of 15 bolls each at fortnightly intervals in the open. No boll formation took place on the shaded plot.

Table 29.

Treatment					Lint Weight per boll	Seed Weight per boll
F	Sodium nitrate	...	...	...	0.45 gms.	0.94 gms.
G	Ammonium nitrate	...	...	...	0.51	1.04
H	Sodium phosphate	...	...	...	0.51	1.04
I	Ammonium phosphate...	...	...	...	0.51	1.14
J	Sodium nitrate + sodium phosphate			...	0.52	1.08
K	Ammonium nitrate + ammonium phosphate				0.51	1.10
L	Sodium nitrate + ammonium phosphate				0.57	1.24
M	Ammonium nitrate + sodium phosphate				0.55	1.20

The two mixed treatments appear to have the most favourable effect, treatment L having the greatest effect both on seed and lint weight.

Fruit Shedding.

As in the N.P. Experiment an estimate has been made (Table 30) of the total percentage shedding, not due to bollworm damage, in relation to total flower production from 22.10.51 to 14.1.52 for each treatment.

Table 30.

Treatment	Shedding	(N.B.W.)
	Open	Shaded
F. Sodium nitrate	6.4	27.2
G. Ammonium nitrate	5.3	23.0
H. Sodium phosphate	3.8	44.9
I. Ammonium phosphate	5.1	19.7
J. Sodium nitrate + sodium phosphate	3.5	20.4
K. Ammonium nitrate + ammonium phosphate...	4.8	16.4
L. Sodium nitrate + ammonium phosphate ...	4.3	18.3
M. Ammonium nitrate + sodium phosphate ...	3.0	19.1

In the open the lowest shedding is by those treatments containing sodium phosphate. Ammonium phosphate appears to cause increased shedding. Under shaded conditions however ammonium phosphate appears to have a certain advantage in reducing shedding.

Conclusions.

In the choice of any particular seed soaking treatment for its general advantages from the results of this very limited experiment, treatment M — ammonium nitrate and sodium phosphate — is superior as it gives a higher growth rate, on the average of open or shaded plants. Flower production is greater in the open and only slightly less in the shade than other treatments, and the lint weight although not quite as high as treatment L is above average. Fruit shedding is the lowest of all treatments in the open and well below average in the shade. It has the disadvantage only of a high defoliation rate in the open.

E. THE "TOKAR EXPERIMENT".

Some of the characteristic features of the cotton crop in Tokar Delta are the excessive vegetative growth shown by some plants and the excessive boll shedding shown by others. These features seem to be the cause of the poor yields normally obtained at Tokar compared with the Gezira.

Jewitt, (4) has pointed out that there was sometimes a very large amount of nitrate nitrogen in Tokar soil, but in general that the level was what one would expect to find in a fertile soil. Although, also, there was nothing to suggest shortage of phosphate in the soil, availability was an important factor. Mollison had applied phosphate by spraying and obtained a small (but not significant) increase with a very small application. The soil pH is high, in the majority of cases lying between 8.05 and 9.0, and highly alkaline soils are considered to render phosphate non-available.

The other factor which undoubtedly has a great influence on the development of the crop and subsequent yield is cloudy conditions which prevail during development. From October to January the cloudiness rises rapidly from about 15 per cent covered to 45 per cent covered (mean of two or three readings per day) which is bound to result in a curtailment of photosynthesis and a consequent carbohydrate deficit for seed and lint formations. The meteorological data is well summarised in a paper by Williams (5).

The possibility of genetic differences in the seed producing boll shedding or vegetative growth had also to be considered, which led to the laying down of this exploratory experiment at the G.R.F. in which (a) seeds taken from normal X1730A Gezira plants were grown under identical conditions with (b) seeds from Tokar plants which behaved normally, (c) seeds from Tokar plants which produced vegetative growth, (d) those showing excessive boll shedding, and finally (e) X1730A seeds from normal plants from the Gash delta. To make Gezira soil resemble to some extent Tokar soil it was treated with 160 rotls N.p.f. as sulphate of ammonia and gypsum 2 tons/feddan. Half of the plants treated were in the open and half were under a sacking shade which was sprayed regularly to maintain a damp atmosphere. Comparisons were made by wet and dry bulb thermometers and Livingston atmometers which showed that the humidity was in fact higher.

Layout.

One angaia was allocated for the experiment and two sub-plots each of 3 ridges planted as follows :— A. — seed from Gezira X1730A ; B. — seed from normal Tokar plants ; D. — seed from plants showing excessive boll shedding in Tokar ; E. — seed from Gash X1730A. Half of the plants were thus exposed to damp shade and the other half were in the open.

Pests and Diseases.

Blackarm was somewhat severe in the shaded plot in the early part of the season and caused defoliation. Most of the plants grew away from this later. Whitefly were very numerous throughout, particularly in December in the damp shade, and at the end of the month wilt set in during a cold spell.

Lint and Seed Weight.

The total weight of seed cotton produced at two pickings on 10th and 24th. February in the open was highest for D. followed very closely by E. The total lint produced was highest for D. also. E. produced slightly less lint and a slightly heavier seed weight. D. produced its highest lint weight and seed on the 10th. while E. showed its maximum on the 24th.

Developmental Analysis.

The salient features of the development of plants from the different seed types are summarised in Table 31.

Table 31.

	Av. Ht. increase cms/week		Node Forma- tion Av/week		Defoliations Av/week		Flower Production Av/week	
	Open	Shaded	Open	Shaded	Open	Shaded	Open	Shaded
A. Gezira. X1730A	3.6	4.4	1.25	1.38	1.03	0.88	3.36	0.50
B. Tokar. Normal	3.7	6.5	1.29	1.29	0.98	0.95	3.72	0.86
C. Tokar. Vegetative	3.2	4.5	1.17	1.29	0.95	0.82	5.0	0.36
D. Tokar. Boll shedding.	3.7	4.7	1.19	1.30	0.82	0.75	2.64	1.04
E. Gash. X1730A	3.3	7.4	1.13	1.30	1.0	0.69	3.86	0.57

It is interesting to note that on 8/10 when these observations commenced Tokar boll-shedding plants and Gash plants in the open were 4 cms. taller than those from other seeds, and Tokar normal plants in the shade were also taller. On this date also defoliation in C. D. and E. both in the open and shade was much higher (5.0 : 0.5 in open and 4.0 — 5.0 : 1.0 — 1.5 in the shade).

If these results are representative of the development of the respective plants in Tokar certain facts can be deduced. The normal Tokar plant apparently grows better in the shade and defoliates more than the boll-shedding plant. Its flower production is less in the open than the vegetative plant but more than twice as great in the shade, although not as great as the boll-shedding plant.

Table 32.

Total percentage Boll shedding. (not due to Bollworm damage).

Seed Origin						Open %	Shaded %
A.	Gezira.	X1730A	...	...	...	6.0	15.7
B.	Normal.	Tokar	...	...	...	7.1	8.9
C.	Tokar.	Vegetative	...	...	...	3.2	21.0
D.	Tokar.	Boll shedding	...	...	...	3.9	6.0
E.	Gash.	X1730A.	...	...	...	7.4	11.0

The shedding of plants whose parents showed boll-shedding characteristics is less than the other seed types in the shade. It is possible therefore that a so-called boll-shedding plant is only so by reason of soil conditions, such as high nitrogen. This received some confirmation from the equally tentative results of the N.P. Experiment.

The Tokar vegetative plant, however, appears predisposed to high shedding under shaded conditions and has a very low flower production when so treated. It is a vegetative plant because it produces a few flowers and has a high shedding rate.

If these suppositions are correct then it would be interesting to observe the effect of nitrogen and phosphate manurial treatments on the different seed types selected for this experiment.

Literature cited.

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V. Statistician's Report

by J. Taylor

1. ROUTINE. Routine summaries and analyses of data collected by the Agronomy and Plant Physiology Section occupied much of the time of the statistical unit. Advice on the design and analysis of experiments was given to members of all sections, and to some members of the field division of the Ministry.

2. LONG-TERM TRIALS. Inspection of the results of long-term agronomy trials, in collaboration with the Senior Agronomist, was continued.

3. SAMPLING METHODS. For some years the yield of dura at Abdel Magid, and on experimental areas at Seleimi and Abdel Hakim, has been estimated by weighing the crop of a few rows selected at random. To investigate the sampling errors involved, eight rows were weighed from each hoshia of the experimental area at Abdel Hakim. Two of the rows were selected at random from each quarter of the hoshia.

An analysis of the results showed that the sampling errors are reduced by stratifying the sample — *i.e.* if two rows are weighed from a hoshia, one should be selected from each half of the hoshia; if four rows are weighed, one from each quarter. According to these data, the yield of a hoshia could be estimated from the yield of four rows (one selected at random in each quarter) with a standard error of under 5 per cent. This should be good enough, especially as experimental comparisons are affected by the variation between hoshias which is much greater than these within-hoshia sampling errors.

4. GEZIRA COTTON YIELDS. In collaboration with Mr. O. W. Snow of Pest Control Ltd., the routine records for the Gezira in recent seasons were analysed to estimate the effect of D.D.T. spraying upon cotton yields. A paper will be published in the Bulletin of Entomological Research.

The method adopted was to regard each S. G. B. block as a replicate of an experiment. For each treatment, the yield in k.p.f. was found for each block and was given a "weight" equal to the area on which it was based. This is the best method available, though any attempt to analyse such data as these (which have not been collected in a planned experiment) is bound to raise theoretical difficulties.

5. YAMBIO. A soil variability trial was carried out at Yambio. The first season's results were analysed and the following recommendations are made. It must be stressed that they are tentative, for they are based only on one season's results on one piece of ground, and that was newly-opened ground carrying crops of groundnuts and beans, but not of cotton. They are put forward only because there are at present, no other data to work on.

- (a) If treatments are not applied until after a germination count has been made, the latter can usefully be taken as the independent variate in an analysis of covariance.
- (b) Otherwise, it should be worth while to record the percentage of anthills and of ironstone outcrop in each plot (if these vary much), and the number of tree stumps, and to do an analysis of covariance on them.
- (c) The randomized block design should be used. It is much more accurate than the method of alternate treated and control strips. Also the use of "incomplete block" designs is not recommended unless the number of treatments is very large.

- (d) The width of a block (measured across the catena) should be about 3 times its length (measured down the catena). Within a block, plots should be side by side, each one being as long as the block is.
- (e) If the number of replications is limited but the total area of the trial is not, an increase in plot size will normally increase the accuracy of the trial. For trials with 8 replicates it is suggested that plots should be at least 81 sq. metres in area.
- (f) If the number of replicates is unlimited but the total area of the trial is limited (or if it is desired to attain a given accuracy in the minimum total area) then the plots should be as small as possible, with a corresponding increase in replication.

VI. Report on the G.R.F. Herd of Kenana Cattle

by M. C. Hattersley.

The health of the herd remained normal throughout the season; two cases of mastitis occurred in old cows but an epidemic was avoided. Inoculations against anthrax and haemorrhagic septicaemia were carried out as usual and bovine pleuro-pneumonia and rinderpest vaccines were given to animals not previously treated.

Twenty-five calves were born during the year of which 5 either died or were destroyed. Eight males and nine females were added to the herd book.

The herd book is a record of the progeny of 6 foundation cows, for which families fairly complete records are available. At 31.12.51 the herd proper consisted of 52 females, 3 stud bulls, and 17 other young males under observation. A few other animals not included in the herd book are also kept, in addition to some 30 tillage oxen.

STUD BULLS.

Atebrin (Born 1939) sired 5 female and 1 male calves born during the year. His last successful service was 13.7.51 and it is suspected that his virility is decreasing.

Cyprus (Born 1943) was on loan to Abdel Magid Scheme. Nine of his female progeny are under observation.

Oskar (Born 1943) is now replacing his sire Atebrin where required; he sired 5 females born in 1951.

Fattah (Born 1948) is now replacing his sire Cyprus.

FEEDING.

Calves were again pail fed from birth. Average weights are given below and it appears that really successful pail feeding requires more constant supervision than is feasible. Individual calf pens are under construction and Solar calf feeders with teats will be installed in an attempt to further eliminate present undesirable features in calf rearing.

Average Wts. for 6 male and 5 female bucket fed calves attaining 6 months of age during 1951 (lbs) (and comparative figures).

	Birth Wt.		6 weeks.		12 weeks		24 weeks	
	M	F	M	F	M	F	M	F
1951	52.0	52.0	108.2	101.2	148.0	141.4	203.0	231.6
1950	56.1	50.0	86.8	90.3	112.1	133.1	214.7	213.8
1949	50.2	46.4	108.2	97.8	153.0	140.7	239.7	221.8
Av. for Suckled calves 1947/48.	50		110		150		220	

Records were kept throughout the year for all weighed issues of foodstuffs to cattle including tillage animals. The failure of the lubia crop in the previous season led to the consumption of all gassab reserves, which were fortunately available. The poor growth of weeds on the fallow areas in this season also led to increased issues of stored fodder. The figures below show that over 138,000 lbs extra dry matter was fed to the herd from stored fodder above the 5 yearly average. The difference in the figure of 2.51 lbs of dry matter issued per 100 lbs. body weight, compared with the average of 2.1 lbs, is assumed to be chiefly due to the lack of rain weeds, and slightly to greater accuracy in the recording of issues under extras.

Issues in lbs of Air-Dry Material 1946/50 and 1951.

	1951	Av: 1946/50
Average herd weight during 1951	85,000	80,000
Dry matter issued per 100 lbs. body Wt. daily ...	2.51	2.11
Dura grain	77,537	89,648
Cake	35,433	59,322
Gassab	512,575	306,653
Lubia hay	58,343	104,627
Extras	68,349	53,713
TOTAL	752,237	613,963

Total Average numbers and classes of animals.
1946/51

Herd Averages	Stud bulls	Other males	Dry Cows	Milk cows	Tillage	Total
1946/50	2	25	37	14	28	106
1951	2	25	45	15	27	115

Milk production.

Av: 1946/1950	76,559 lbs.
1951	80,290 lbs.

The low figures for concentrates and lubia issues show an economy which has in no way been detrimental to the milk yields and, although the concentrate figures include issues to all stock, the issues to tillage animals are fairly constant over the years and variations are mainly due to milk cows.

The more careful allocation of fresh grazing, included under lubia hay and extras as dry weight, is also an important factor in the economy of concentrates in milk production.

A Fullwood and Bland Midget electric milking machine is being obtained.

MILK YIELDS.

Lactations ending in 1951. (All yields)

Atehrin females

Calf No.	Cow			Days	Lbs. yield	Av : lbs./day.
1	Annabella	...	...	274	5230	19.1
2	Ogda	...	...	225	3183	14.1
2	Eva	...	...	118	1588	13.4
3	Fahtma	...	...	202	4107	20.3
3	Istrahna	...	...	153	2838	18.5
1	Cynthia	...	...	323	6240	19.3
1	Jacaranda	...	...	308	4716	15.3
1	Agnes	...	...	199	2781	14.0
1	Alowa	...	...	192	2113	11.0
	Av: ...			221	3644	16.1

Said females

4	Faiza	...	...	160	3074	19.2
7	Angeila	...	...	284	4776	16.8
5	Eritrea	...	...	266	4601	17.3
3	Arabia	...	...	341	6645	19.5
5	Roma	...	...	216	3750	17.3
	Av: ...			253	4569	18.0

Cyprus females

1	Amy	...	...	289	4486	15.5
1	Ophelia	...	...	284	3871	13.6
	Av: ...			286	4178	14.5

Other sires.

Calf No.	Cow				Days	Lbs. yield	Av : lbs/day (and Sire)	
8	Jaleila	...	...	...	219	4234	19.3	(Baba)
9	Arusa	...	...	...	238	5252	22.1	(Baba)
1	Jawhara	...	...	...	272	4443	16.3	(Zakaria)
12	Om Rish	...	...	...	260	3711	14.3	
(Foundation Cow)								
Av :				...	247	4410	18.0	

When comparing daughter yield averages for sires *Atebrin* and *Said* it should be noted that the lactations recorded for *Atebrin* are from earlier calvings.

				Days	Lbs. yield	Av : lbs/day.
Average for	1951	...	...	252	4200	16.6
	1950	...	...	243	4175	17.1
	1949	...	...	260	3748	14.3
	1948	...	...	221	3414	15.4
	1947	...	...	180	2950	16.8

SECTION OF BOTANY & PLANT PATHOLOGY

A. Economic Botany

by *K. Wilson Jones*

CONTROL OF LAND WEEDS

1. CONTROL OF SEID GRASS EXPERIMENTS.

Observations were continued on the long-term eradication experiment at Wad Asha. A considerable amount of improvement was noted, as compared with previous years, but the late and scanty rains made estimation of seid grass coverage difficult. It is very difficult to estimate from results up to date whether virtual eradication of this weed will eventually be attained by deep ploughing, but it seems probable that the eventual control obtained will fall considerably short of that which was originally hoped for.

2. CHEMICAL CONTROL OF WEEDS.

Following the visit of Dr. W. G. Templeman in 1950 and his suggestions for further work on the use of herbicides against the grasses of the rainlands, supplies of the following chemicals were kindly presented by Messrs. Plant Protection Ltd.

2;4-D Sodium salt powder

Isopropyl phenyl carbamate ("IPC")

Sodium trichloroacetate ("TCA")

Experiments were drawn up consisting for simplicity of two identical fields each at Ghadambaliya, Um Suqura, and at Dugein in the Gash Delta. The plan was that at each site, one field should be treated before any appreciable amount of rain had fallen (before the flood in the case of the Gash) and the other should be treated at the time of first appearance of the grass seedlings (or as soon possible after the Gash flood).

Treatments were as follows :—

- A. IPC at 10 lbs. per feddan.
- B. IPC at 20 lbs. per feddan.
- C. IPC at 10 lbs. plus 2;4-D at $2\frac{1}{2}$ lbs. per feddan.
- D. IPC at 10 lbs. plus 2;4-D at 5 lbs. per feddan.
- E. IPC at 20 lbs. plus 2;4-D at $2\frac{1}{2}$ lbs. per feddan.
- F. IPC at 20 lbs. plus 2;4-D at 5 lbs. per feddan.
- G. TCA at 20 lbs. per feddan.
- H. TCA at 50 lbs. per feddan.
- J. Control — no chemical treatments.

Each field consisted of 36 sub-plots giving four replicates of each treatment.

Ghadambaliya.

The old grass on the selected area was burned off and the fields measured and marked off during April 1951. Clean bare ground was thereby left for the spray application.

Both here and at Um Suqura the sub-plots were 20 × 10 metres in size. After the main rains had become established, crops were sown as follows :—

- Block 1 not sown.
 „ 2 sown when soil moisture sufficient.
 „ 3 sown 2 weeks after block 2.
 „ 4 sown 2 weeks after block 3.

Each sub-plot was sown in three strips, consisting of dura, cotton, and sesame, and germination and growth observed. It was hoped that these experiments would show (a) the feasibility or otherwise of using chemicals either alone or to assist mechanical cultivation in opening up new grassland, with the corollary that previously cultivated (komodob) land might even more easily be cleaned, and (b) the time which would need to elapse after the treatment before any of the three principal rainland crops might be sown.

Owing to the late arrival of the IPC some anxiety was felt that the earliest rains might germinate the grass before spraying could be completed on the early-treatment field, but all except the high rates of IPC were sprayed before the first heavy rain fell; these plots were treated as soon as the ground was sufficiently dry for men to walk upon and all the first spraying was completed by July 21st. The only seedlings appearing at the time of spraying were a few *Commelina kotschyi*, Hassk. with very occasional anis grass (*Sorghum purpureo-sericeum*, Aschers and Schw.). Drought then supervened and these few plants died off even where not treated. Later rain resulted in more general germination of the grasses, which were recorded as follows :—

Total plant cover, estimated per cent.

Treated 21.7.51.

Date	Treatment								
	A	B	C	D	E	F	G	H	J
19.8.51	1	2	P	P	P	P	P	P	6
25.8.51	4	9	P	1	2	P	2	2	9
1.9.51	10	14	3	P	4	P	2	3	23
8.9.51	12	21	4	P	5	P	3	3	25
15.9.51	25	36	4	P	10	1	12	8	40
22.9.51	28	40	13	13	11	1	13	8	44

P = present, less than 1 per cent.

Among this general cover anis was present as follows

Date	Treatment								
	A	B	C	D	E	F	G	H	J
19.8.51	very few	fair	very few	very few	very few	very few	very few	very few	few
25.8.51	fair	fair	very few	NIL	very few	very few	very few	NIL	very few
1.9.51	very few	few	very few	NIL	very few	very few	very few	NIL	very few
8.9.51	very few	few	very few	NIL	very few	very few	very few	NIL	very few
15.9.51	few	few	very few	very few	few	very few	very few	very few	fair
22.9.51	heavy	very heavy	fair	few	heavy	fair	heavy	fair	very heavy

Scale :— Very Heavy, Heavy, Fair, Few, Very Few, Nil.

Block 2 was sown on 17.8.51 without result; rats and insect pests were apparently responsible. The sowing was repeated on 31.8, without weeding, after more rain had fallen. Germination was uniformly good except in the case of the dura on treatments D, F and H, where only a moderate stand was obtained. Block 3, sown on 17.9, showed good germination of the crops under all treatments. Block 4 also gave good germination throughout.

The second field at Ghadambaliya was sprayed on 6.8 when the grass seedlings were first beginning to appear. Observations were carried out as for the previous plot.

Total Plant Cover, estimated per cent.

Treated 6.8.1951

Date	Treatment								
	A.	B	C	D	E	F	G	H	J
19.8.51	6	4	P	P	P	P	5	1	7
25.8.51	9	10	P	P	P	P	1	5	8
1.9.51	17	18	1	P	P	P	3	3	21
8.9.51	19	19	2	P	P	P	4	4	23
15.9.51	38	41	10	1	5	1	8	11	43
22.9.51	43	36	10	1	5	2	9	14	44

P = present, less than 1 per cent.

Estimated frequency of anis

Date	Treatment								
	A	B	C	D	E	F	G	H	J
19.8.51	few	few	very few	NIL	very few	NIL	very few	very few	fair
25.8.51	very few	few	NIL	NIL	NIL	very few	NIL	NIL	few
1.9.51	very few	NIL	very few	NIL	NIL	very few	NIL	NIL	few
8.9.51	few	NIL	very few	NIL	NIL	very few	NIL	NIL	few
15.9.51	few	very few	very few	very few	very few	very few	very few	very few	fair
22.9.51	fair	very heavy	fair	few	heavy	fair	heavy	fair	very heavy

Scale:— Very Heavy, Heavy, Fair, Few, Very Few, Nil.

The crops sown on 31.8 on this field germinated and grew well with the exception of the dura on treatments B, E and F, on which no germination was recorded. This seems to be definitely due to the residual effect of the IPC at the higher strength. It is interesting to note that this is the only case recorded in these experiments where the IPC had a positive effect. Sowings on 17.9 showed uniformly satisfactory growth of all crops.

It seems most reasonable to consider the time recorded for breakdown of the chemical to date from the first recorded appearance of the weeds, since but little breakdown can have occurred until the moisture content of the soil rose sufficiently for germination to commence. This is borne out by the fact that completely satisfactory germination of the dura was not obtained until a similar sowing date under both dates of spraying. On this basis the time required is about four weeks in both instances. On the other possible basis, the difference between the latest date of spraying and the earliest date of successful sowing, six weeks are required for dura sowing and four weeks for the other two crops.

The effect of the IPC applications is rather disappointing; very small differences, if indeed any, are to be seen between these treatments and their control. On the other hand, the effect of the 2; 4-D is well marked. It is a pity that extra plots, sprayed with 2; 4-D alone, were not included, since 2; 4-D shows the most satisfactory reduction of total weed cover, including anis. This is no doubt on account of the grasses being annual grasses, whose seedlings are susceptible although the more mature plants are not.

Um Suqura (in co-operation with I.E. Darter.)

At this station, situated in a region of higher rainfall than the former, the chemicals arrived too late for the pre-emergence spraying to be carried out, and accordingly only one of the two prepared plots was used for the experiment. The treatments were the same as in the second Ghadambaliya plot, and were carried out on 16 — 21 July 1951.

The best immediate result was given by the TCA treatments, which killed all plants except some tufts of perennial *Pennisetum* sp., a bulbous *Scylla*-like plant, and *Cephalocroton cordofanus*, Hochst. Some of the anis was killed by the IPC treatments alone, but the dicotyledons, principally *Ipomoea* spp., were not killed by this chemical without the addition of the 2; 4-D.

Plots graded in order of vegetative cover

Treated 16-21/7/51

Date	Treatment								
	A	B	C	D	E	F	G	H	J
24.7.51	9	8	3	6	4	6	5	2	1
1.8.51	8	9	3	3	6	1	3	1	7
11.8.51	9	8	7	4	6	4	2	1	3
21.8.51	9	6	3	2	3	1	6	5	8

J = Hand hoed throughout.

Anis as per cent cover

Date	Treatment								
	A	B	C	D	E	F	G	H	J
25.7.51	60	53	28	42	21	37	12	13	2
1.8.51	60	49	23	36	19	29	1	0	6
21.8.51	90	75	23	19	19	17	0	0	15

Block 2 was sown on July 23rd. Germination was generally unsatisfactory. On Block 3, sown on August 7th., however, all treatments except the ones containing 2; 4-D allowed satisfactory growth of the crop plants to take place; on the 2; 4-D plots none of the crops grew or germinated well. The crops sown on 21st. August on Block 4 all showed good growth. At Um Suqura the IPC and TCA thus persisted from 21.7 until 7.8 — 17 days, and the 2;4-D until 31 days from the time of application.

The Gash Delta.

In conjunction with the foregoing, it was considered desirable to test if chemicals could alleviate the difficulties encountered in the Gash Delta from weeds. Heavy weed springs up during the early rains or during the flood itself where land is lightly watered, and weeding by any means is out of the question until the surface of the land has dried sufficiently for men and machines to get on to it. Hand weeding costs are high, as much as £E. 4 per feddan being paid for a single weeding. The weeds are mostly grasses and seid (*Cyperus rotundus*).

Two plots, as in the rainlands experiments, were laid out in Dugein Block, each containing four replicates of the same nine treatments as before. The first of these was treated before, the second after the flood. Spraying was carried out by knapsack sprayers, sufficient water being used to ensure thorough suspension or solution of the material and good coverage of the land. The sub-plots were each surrounded by an earth bank, and channels provided so that in the first instance each plot received water which had not passed through adjoining sub-plots. The site of the experiment was so chosen as to avoid the scour in the main stream of the flood.

Spraying was completed between the 18th. and 20th. of July on the "pre-flood" plot. No difficulties were encountered, and insufficient rain had fallen to germinate any weeds up to that date. The flood arrived on July 24th. but, owing to the irregularity of the river flow, watering had to be twice suspended and was not completed and the ground dry until September 8th.

Weed Observations. Estimated per cent cover over 4 replicates.

Date	Treatment								
	A	B	C	D	E	F	G	H	J
4.8.51	76	78	53	45	48	25	75	53	88
8.9.51	89	82	43	50	51	30	71	60	83

Among the grasses were the following:— *Paspalidium desertorum*, Staph., *Chloris* spp., *Pennisetum* spp., *Sorghum* spp., and *Echinòchloa colona*, Link.

All the cotton germinated satisfactorily after the flood. Under all the 2;4-D treatments C, D, E and F, a few plants showed symptoms of slight 2;4-D injury on the early leaves. The results of the weed observations showed that, though some control was obtained, this was quite inadequate as a practical method of control for general use.

The second plot was sprayed on 9.9.51 as soon as the ground was dry enough for the men to walk on it. The cover of the mixed grasses by then stood at a height of about 30 cms. All weeds under all treatments showed considerable yellowing and browning of the leaves after three days. Tops were for the most part killed, but after 7 days it became obvious from the signs of regrowth that no permanent damage had been done. The experiment was accordingly abandoned.

It is apparent that much of the chemical applied to the "pre-flood" plots had been leached by the flood water and most of the effect lost; otherwise a similar result to that of the rainlands experiments would no doubt have been obtained. As for the "post-flood" sprayings it is doubtful if any of the chemical could have really penetrated into the soil in the absence of rain. It is concluded that none of the chemicals included in the present trial are really suitable for the control of weeds under the conditions of the Gash Delta.

Gezira Research Farm.

To provide a parallel with the rainlands and Gash Delta experiments, a small experiment was run on a part of Plot 78, G.R.F. using the same eight treatments, with control, as before. Plots were each 1/24th. feddan in area and there were three replicates. Only the effects on the weeds were studied; no crops were sown.

The 2; 4-D and TCA were sprayed on 4.6.51, and the low rate of IPC on 15.6. Owing to the late arrival of the main quantity of IPC, the 20 lb. rate of this chemical could not be applied until 10.7. Up to this time only negligible rain had fallen.

During the following months, owing to the lack of sufficient rain and the heavy cracking of the soil absorbing the little which fell, weeds failed to germinate. In mid-August a light watering was given to the plots in an attempt to close the cracks and germinate a certain amount of weed. When rain finally fell, and a light weed cover resulted, observations were carried out throughout its duration. On October 17th. the cover reached its maximum, with an estimated percentage cover as follows :—

Estimated weed cover per cent October 17th. 1951.

Block	Treatment								
	A	B	C	D	E	F	G	H	J
I	55	70	15	7	15	28	25	25	65
II	50	52	35	15	20	15	25	12	40
III	40	47	18	12	15	6	15	18	55
Means	48	56	23	11	17	16	22	18	53

Minimum significant difference @ 5 per cent = 14.1.

The IPC, as in the rainlands, was without effect. The other chemicals showed a significant difference. This is not unexpected in the case of the 2; 4-D, for it has been shown in previous experiments,

but in the case of the TCA it is apparent that dicotyledonous seedlings as well as grasses are susceptible to soil treatments. The main weeds on the plots, in order of importance, were :—

- (1) *Oldenlandia strumosa*
- (2) *Acalypha indica*
- (3) *Corchorus fascicularis*
- (4) *Phyllanthus niruri*
- (5) *Echinochloa colona*

Only the last of these is a grass. No selectiveness of emergence of weed species under the different treatments could be distinguished.

Discussion

The results of these weed-killer experiments have shown that in the rainlands it is possible, if costs are ignored, to cultivate chemically and obtain reasonable stands of crop plants without encountering excessive trouble from the persistence of the chemicals in the soil. Both at Um Suqura and at Ghadambaliya, spray applied at about the time of first emergence of the weeds — *i.e.* when the soil is moist — requires about four weeks to be rendered innocuous to the crop by soil breakdown. In the Gash the leaching is very heavy, and most of the weedkiller is lost by this means before it has had time to perform its work.

In all these experiments the IPC failed. This is very disappointing, and it would seem, in view of its performance in temperate countries, that it is not sufficiently stable under Sudan conditions of temperature for use here; alternatively, there may be some unknown effect of the clay.

The failure of the TCA and 2; 4-D to control *Cephalocroton cordofanus* at Um Suqura is to be noted. It was hoped that the 2; 4-D might prove itself useful in dealing with this highly aggressive and cultivation-resistant weed, which has the power of repeatedly regrowing from its massive tap-root system. It is known from other experiments that this weed is resistant to sprays applied to the foliage; heavy early applications at the beginning of the season are also here shown to be useless.

Commelina kotschy Experiment.

Plot 8, G.R.F., was sown with main crop dura and an extraordinarily heavy growth of *Commelina kotschy* appeared among the crop, forming a solid mat on the ridge tops and covering about 60 per cent of the soil surface. A small amount of each of the following weeds was also found :— *Tephrosia lathyroides*, *Phyllanthus niruri*

and *Heliotropium* sp. A number of hormone weed-killer compounds were tested at the rate of 1 lb. of active agent per feddan, each on one $\frac{1}{4}$ — feddan angaias as follows :—

(1) Sodium MCPA salt.	}	Presented
(2) Ethyl 2; 4-D ester.		by
(3) Butyl 2; 4-D ester.		Messrs. Plant Protection Ltd.
(4) Sodium 2; 4-D salt.		and
(5) 2; 4-D amine salt.		May and Baker Ltd.

Operations were as follows :— sowing 3-4.8 spraying 26-27.8; harvest (heads) 8.11; harvest (gassab) 1.12.

Within one day of spraying it was apparent that with the exception of the *Commelina* and the occasional grasses, all weeds were showing epinastic effects. After 1 week most of these were dying or dead, and the *Commelina* was turning yellow and wilting under all treatments except the sodium 2; 4-D. The success of the kill of the *Commelina* was assessed among the treatments as followe :—

(1) Ethyl ester 2; 4-D	Mostly dead
(2) Butyl ester 2; 4-D	" "
(3) 2; 4-D amine salt	50 per cent killed
(4) Sodium MCPA	" "
(5) Sodium 2; 4-D	Yellow a little.

By 10.9 it was apparent that a certain amount of damage had been caused to the dura, particularly by the ester formulations, where the leaf laminas appeared to be "frilled" between the veins, as though the growth-rate of the veins had not kept pace with that of the lamina. A little of this effect was noted under all treatments, but nowhere so strongly as among the ester-treated plants. The difference in effect of the chemicals on the *Commelina* persisted throughout the lifetime of the crop, and though the amount of this weed on the controls become less as the season advanced, the sodium-salt-treated weed, though yellow, continued to live. By 18.9.51, 22 days after spraying, the estimates of general weediness were as follows :—

Sodium MCPA	15 per cent
Ethyl 2; 4-D	15 per cent
Butyl 2; 4-D	15 per cent
Amine 2; 4-D	15 per cent
Sodium 2; 4-D	60 per cent
Unweeded Controls	80 per cent

At harvest it was considered useful to note the yields though as the plots were not replicated little reliance can be placed on the differences which occurred. Considerable variation was shown in the fertility of the plots, and probably the best guide to the treatment effects is given by comparing each treated angaia with the adjoining untreated angaia and giving the result as percentage of the control. The mean yields in r.p.f. over both treated and control angaias were :—

No. of ripe heads per feddan	45066
Wt. of ripe heads per feddan	2560
Wt. of gassab per feddan	5130

Yields as per cent of adjoining control angaias

Treatment	No. of heads	Wt. of heads	Wt. of gassab
Na. M.C.P.A.	96.7	71.3	114.9
Ethyl 2; 4-D	86.8	69.0	81.2
Butyl 2; 4-D	81.1	97.1	126.4
Amine 2; 4-D	112.2	111.1	102.0
Na. 2; 4-D	104.5	85.7	78.2

It should be borne in mind that in the sowing of the crop none of the usual precautions had been taken to equalise the numbers of plants, and at the time of treatment the weed had probably done most of the damage of which it was capable. Had treatment taken place earlier the improvement due to killing of the weeds would probably have masked the damage caused by the treatments.

The only chemical showing an overall increase in yield is the amine, generally regarded as more toxic than the sodium salts. The lowest yields throughout are those given by the ethyl ester, probably due to its toxicity. The fact that the sodium 2; 4-D has given a low yield is probably as a result of its failure to control the *Commelina* in addition to its toxicity to the dura.

As an incidental to the experiment, it appears that ester formulations are too toxic for use in the Gezira, for extensive leaf deformation occurred among cotton sown on a neighbouring plot.

CONTROL OF WATER WEEDS

TURABI CHEMICAL EXPERIMENT WITH 2; 4-D.

In early April 1951 a number of canals were treated in Turabi sub-division in co-operation with Messrs. Lane and Watts of Plant Protection Ltd., to ascertain the effects of varying dosages and methods of application of 2; 4-D powder and solutions. Plant Protection Ltd. kindly supplied a dusting and a spraying machine.

The dusting machine was mounted on a raft, and carried a hood made of hessian to eliminate drift. Though under trials in England it gave excellent results, under Sudan conditions the particles clogged the pores of the hessian and caused trouble. Very little treatment was therefore carried out with it.

The spraying machine was provided with a long boom which reached across the canals, with the motor and spray tank carried on a lorry alongside. This was used for some sodium 2; 4-D solution and some 2; 4-D amine salt solution.

The most satisfactory arrangement for the application of the sodium 2; 4-D powder was found by trial to be "sludging"; the boom of the sprayer was removed and a small nozzle substituted at the end of the hose. In the spray tank, continuously stirred, was placed the required amount of powder for the unit length of canal, in a minimum quantity of water. As the solubility of the material in water is only about $2\frac{1}{2}$ per cent, a heavy suspension could thus be sprayed or rather squirted over the entire surface of the canal from the bank.

Another minor canal was treated with 80 per cent sodium 2; 4-D dust by hand. All the mechanical applications were carried out by Messrs. Lane and Watts.

It was found during the early measurements of the canals, that there was a much greater variation in the cross-sections than had previously been anticipated. As a final precaution, further measurements were made after application and the actual amounts applied were recalculated as parts per million after application. It was intended that amounts up to 15 p.p.m. should be used on various canal reaches; actually $17\frac{1}{2}$ p.p.m. was the highest amount applied.

The following is a summary of the results as observed in March 1952:—

- (1) The amine salt of 2; 4-D at strengths up to 15 p.p.m. proved ineffective. The plant tops were not killed as rapidly as in the case of the sodium salt powder, and regrowth occurred as soon as water was readmitted after the summer closure.
- (2) The only other treated canal which grew weeds almost immediately on reopening of water, was Abu Jebel, treated carefully by hand with sodium 2; 4-D powder in 1951 as well as previously in 1950.
- (3) With the exception of these two canals, all the treated ones remained clear of weeds up to and including November 1951. By December, however, although no growth of angiosperms occurred, a heavy growth of *Chara globularis* had commenced, which continued and gave trouble during January and February 1952. About two kilometres of *Chara*-infested canal, treated as an experiment with copper sulphate in February, confirmed the results of two years ago, that 10 p.p.m. will kill some but not all of the alga, and that 20 p.p.m. are required to obtain an effective kill.

- (4) In these latter canals small quantities of angiospermous weeds began to appear in March 1952; the quantities were in most cases very much less than in March 1951. The actual length of canal clear of all weed except *Chara* was 7.2 Kms. in March 1952 against 5.3 Kms. in March 1951, out of approximately 32 Kms. treated. *Chara* was present in 17 treated reaches in 1952 against 6 in 1951 out of 24 treated.
- (5) Hope of a satisfactory control of the water weeds by means of Fernoxone seems to be receding. Though the angiospermous weeds have been heavily reduced in the present season, the heavy growth of *Chara* which followed has more than counterbalanced the advantage so derived. In any case the high cost of treatment would be uneconomic unless almost 100 per cent kill was obtained, and the results so far do not approach this figure. Experiments are however continuing.

AROMATIC SOLVENTS.

20 galls. of aromatic solvents, corresponding to the American specifications for weed control work, were received in February 1952 from Messrs. I.C.I. Ltd., and applied in co-operation with their representatives on three canals in the Turabi sub-division.

The solvents, suitably emulsified, were applied as an underwater spray to the canal beneath the water surface at a measuring weir or bridge, for varying times, and to give various concentrations in the water flowing downstream. Three experiments were carried out.

- (1) 4 galls. of solvent were applied to water flowing at 1 cu. metre per minute (Factor 1440) over 1 hour to give a concentration of 300 p.p.m. in the treated water. After one week, only the weeds immediately below the weir seemed to be affected. The canal was very full of water at the time of treatment.
- (2) 4 galls. of solvent were applied over a 1 hour period to water flowing as above, below a pipe bridge in a neighbouring canal; the water level in the canal having first been dropped as low as possible without exposing the weeds. After 1 week damage to *Potamogeton crispus* tips was visible more than 800 metres below the point of application, and *Chara globularis* was killed more or less completely up to 600 metres. Three days later both weeds were killed or heavily damaged up to 600 metres; below this point various degrees of recovery were visible. Some *Potamogeton perfoliatus*, present in the canal, appeared to be substantially unaffected by the treatment.
- (3) 8 galls. of solvent were applied over a $\frac{1}{2}$ — hour period to water flowing at 2 cubic metres per minute over a measuring weir, to give a concentration of 600 p.p.m. in the water. $1\frac{1}{2}$ hours after the first application, a further 4 gallons was applied at the head of the mass of treated water as it flowed downstream, to maintain its strength. *Potamogeton perfoliatus*, the principal weed here, was unaffected. The small amount of *Chara* which was present was killed.

The use of these solvents seems to have some promise against *P. crispus* and *Chara* as in emergency treatment.

WEED OBSERVATIONS ON THE FALLOW HOEING EXPERIMENT.

This experiment is now in its sixth year, and so far no very outstanding effects on the flora have been recorded as a result of the hoeing. The general impression gained among the Gezira Inspectors that fallow weeding increases the frequency of seid (*Cyperus rotundus*) has during the past three years been shown to be due, not to an increase in numbers of plants of this weed over the treated howashas, but to its thereby being made more easily visible by the removal of other weeds. Slight increases in some places are more or less balanced by decreases in others; for example Remeitab shows an average increase of infestation at the time of weeding from 7 plants to 15 plants per square metre, but Tayiba shows a reduction from 14 to 11, Turabi a reduction from 12 to 10, and Feteis a reduction from 34 to 21. Abdel Galil shows no differences, being 22-23 plants per square metre throughout.

Moleita (*Sonchus cornutus*, L.), which in 1948 was reported as possibly on the increase, still appears only in small numbers, possibly due to preferential grazing by animals.

One interesting feature of the flora in general is the case of the two main dominant species of the Gezira fallows. In 1949, a year of poor rain, *Acalypha indica* and *Phyllanthus niruri* shared dominance at Remeitab; *Phyllanthus* was common throughout the Gezira but *Acalypha* was virtually restricted to Remeitab, Tayiba and Abdel Galil. In 1950, with good rainfall, the position remained essentially the same with regard to the distribution of these weeds; but at Remeitab the *Acalypha* dominated all others and much of the *Phyllanthus* was suppressed. In 1951, again with poor rains, *Acalypha* was still the dominant mid-season weed. Only future observations will show if this sudden rise in importance of *Acalypha* at Remeitab is a transient phenomenon or whether it constitutes part of a long-term change in the flora of Remeitab. It is the more interesting since, though the rainfall varied during these years, the mid-season count of weeds has always remained around 500 plants per square metre. This figure may be a measure of the weed-carrying capacity of the land, dependent only on rainfall above a certain minimum.

A comparison of the maximum numbers of weeds per square metre, calculated as the mean of 24 square metres of unhoed fallow during the past three seasons shows:—

Block	1949	1950	1951
Remeitab	500	500	480
Tayiba	160	280	280
Abdel Galil	130	290	110
Feteis	220	200	180
Turabi	110	360	190

It is not possible to make a really satisfactory measurement of the reduction in weed growth on the fields which have been weeded at every fallow since 1946, as a fresh weeding takes place each year as soon as the weeds have come up in quantity. However, an estimate can be obtained by taking the weeds present on the treated and control howashas at the time just before the current season's weeding occurred.

Mean weeds per square metre at weeding time, 1951.

Block					Control	Weeded	Reduction
Remeitab	...	...	...	...	420	270	36%
Tayiba	...	...	...	...	270	170	37%
Abdel Galil	...	...	...	...	110	95	14%
Feteis	...	...	...	...	180	130	39%
Turabi	...	...	...	...	Weeded before 1st observation		

Mean weeds per square metre at weeding time, 1950.

Block					Control	Weeded	Reduction
Remeitab	...	...	...	...	350	220	37%
Tayiba	...	...	...	...	90	75	17%
Abdel Galil	...	...	...	...	290	120	59%
Feteis	...	...	...	...	190	140	26%
Turabi	...	...	...	...	250	190	24%

The average effect of weeding, as measured by reduction in weed numbers was 32 per cent in 1951 (excluding Turabi) and 33 per cent in 1950. It seems that this may be as far as the process of reduction of weeds will go, but more seasons will be required for confirmation.

GEZIRA BOARD FALLOW SPRAYING EXPERIMENT

An experiment was planned in conjunction with the S.G.B. to test the effect of spraying hormone weed-killers on fallows to ascertain the feasibility of this method of carrying out large-scale fallow weeding. Owing to the extremely late onset of the rains the weed-killer application threatened to overlap with the cotton sowing and, in order to make at least some trial of the chemicals, two 90 feddan fields were treated in Barakat and Darwish blocks before appreciable weed had appeared. One of these was treated with MCPA, the other with 2; 4-D, both at 1 lb. of active ingredient per feddan,

During the rains which followed, the field treated with MCPA became heavily waterlogged, which masked all effect of the spraying, but the early weed on the 2; 4-D plot showed a reduction in cover estimated at 50 per cent. Two weeks later, however, the weed on the sprayed area had recovered and no differences were visible as a result of the treatment.

The experiment will be repeated during 1952/3, but applications will only be made after weed cover is established.

WEED KILLERS AGAINST STRIGA

A paper has been submitted on this subject to the Empire Journal of Experimental Agriculture. Three main experiments have been carried out, in continuation of the experiment at the G.R.F. in 1947/8, in which increases in yield of dura gassab were recorded as a result of spraying the crop 14 to 28 days after sowing with 1 to 2 lbs. per feddan of Methoxone (MCPA). The first experiment, carried out at Nuri Pump Scheme by Botany staff, gave yields of 550-600 r.p.f. of heads of dura (variety Abu Sabain) on the plots treated with either MCPA or 2; 4-D at 1 lb./feddan, and no heads at all on the untreated plots. The corresponding yields of gassab averaged 11,500 r.p.f. on the treated against 4,500 r.p.f. on the control plots. Infestation was reduced from 79 per cent on the controls to 31-37 per cent on the treated plots. The differences in response to the two chemicals were not significant. At the G.R.F. similar treatments killed much of the Feterita dura, due to the extreme conditions of thirst under which the crops were sprayed. At Fatisa, 2; 4-D treatments carried out by tenants under the supervision of the White Nile Schemes Board staff, of from $\frac{3}{4}$ to $2\frac{1}{2}$ lbs. per feddan, at varying dates, gave increase of Feterita dura heads ranging from 138 rotls to 582 rotls and in gassab from 363 rotls to 1956 rotls. *Striga* infestation was at the same time reduced by from 44 per cent to 97 per cent under the various treatments.

HORMONE RESISTANT LEGUMES

A number of legumes were tested in plots for their resistance to the hormone-type weed-killers, in view of the possibility of future use of herbicides against *Cuscuta*. The following were found to be resistant to $\frac{1}{2}$ and 1 lb. per feddan spray rates of both MCPA and 2; 4-D :—

pea	(<i>Pisum sativum</i>),
cowpea	(<i>Vigna</i> sp.),
groundnut	(<i>Arachis hypogoea</i>);
berseem	(<i>Medicago sativa</i>) was resistant to the $\frac{1}{2}$

lb. per feddan rate only.

The following were susceptible at both rates of spraying :—

lubia afn	(<i>Dolichos lablab</i>),
fasulia	(<i>Phaseolus</i> sp.),
ful Masri	(<i>Vicia faba</i>).

ROOT PENETRATION OF DURA

A few pits were dug on the M.C.P. Schemes in Gedaref district to obtain preliminary information on the development of dura roots in relation to cultural treatment. The pits, nine in all, were dug towards the end of the season as the grain was ripening, when it was expected that the roots would have attained most of their development. Too wide a range of conditions was sampled for many conclusions to be drawn in regard to relative development; results were as follows :—

Feterita Maatuk.

- Site A, Ghadambaliya Jebel. Rainfall 420 mms. Discd, virgin.
Sown 3.9.51, observed 18.11.51, 76 days old.
Radius 40 cms. Depth 30 cms.
- Site B, Ghadambaliya Jebel. Rainfall 420 mms. Discd, komodob.
Sown 22.8.51, observed 19.11.51, 89 days old.
Radius 45 cms. Depth 45 cms.
- Site C, Ghadambaliya Jebel. Rainfall 502 mms. Harig, virgin.
Sown 23.8.51, observed 20.11.51, 75 days old.
Radius 55 cms. Depth 40 cms.
- Site D, Ghadambaliya C.7 Rainfall 397 mms. Harig, Virgin.
Sown 9.9.51, observed 22.11.51, 75 days old.
Radius 40 cms. Depth 35 cms.
- Site G, Um Suqura. Rainfall 678 mms. Discd, komodob.
Sown 19.8.51, observed 22.11.51, 102 days old.
Radius 50 cms. Depth 50 cms.
- Site H, Um Suqura. Rainfall 678 mms. Discd, virgin.
Sown 27.8.51, observed 29.11.51, 94 days old.
Radius 50 cms. Depth 60 cms.
- Site J, Um Suqura. Rainfall 678 mms. Discd, fallow discd.
Sown 12.8.51, observed 30.11.51, 100 days old.
Radius 50 cms. Depth 60 cms.

Mugud.

- Site E, Ghadambaliya Jebel. Rainfall 397 mms. Harig virgin.
Sown 27.8.51, observed 24.11.51, 89 days old.
Radius 65 cms. Depth 60 cms.
- Site F, Um Suqura. Rainfall 678 mms. Discd, virgin.
Sown 20.8.51, observed 27.11.51, 100 days old.
Radius 65 cms. Depth 65 cms.

The first and most surprising feature is that no great correlation between depth of penetration and rainfall exists, and that root penetration is dependent, according to these data, entirely on the age of the plant. Graphed out as age against root penetration for the Feterita it is apparent that most of the points lie on a straight line, and the differences found in root penetration are almost completely expressible as a function of the age of the plant. The two observations on the

Mugud seem to lie on a more or less parallel line with greater development and more vigorous growth. The growth rate of the roots up to the time of digging is 0.76 ± 0.25 cms. per day estimated from the regression coefficient.

The superiority of harig, komodob, and fallow disced land, at least in so far as root development goes, seems to be due to the earlier sowing thereby made possible. A larger series of observations may of course show other subsidiary effects.

IDENTIFICATION OF SUDAN PLANTS

Two collecting expeditions were made in the Acacia tall-grass country of the Central Sudan. The first was at Um Suqura in Gedaref District, where 157 plants were collected during the rains. These have been provisionally identified and duplicates sent to Kew for checking; the provisional check list is now available, representing most of the herbaceous flora of the M.C.P. Scheme and its environs.

A second expedition visited Jongol's Post, Upper Nile Province (between Melut and Kurnuk), during the rains, and collected within 10 miles radius. These plants, 202 in number, were collected in an area which according to Broun and Massey contains many plants not found elsewhere in the Sudan, and it is hoped that this collection will yield many plants of interest. Their identification is still pending.

The herbarium dealt with 519 submitted specimens during 1951, and as reorganisation proceeds it is expected that this number will increase annually. All the specimens are being grouped in separate species covers, and individually catalogued for ready reference. Many of Broun's and Crowfoot's original specimens, which were in a poor state of preservation, have been remounted, and many duplicate specimens set aside for possible exchange purposes later.

(B) PLANT PATHOLOGY

by S. A. J. Tarr

1. PLANT DISEASES IN THE GEZIRA

A. COTTON.

1. *Blackarm* (*Xanthomonas malvacearm* (E. F. Sm.) Dowson).

This disease was widespread and more severe than for many seasons past. Parts of the southern Gezira were heavily infected and must have suffered appreciable loss of crop. Due to severe blackarm in some of the X1730A cotton areas of the Gash Delta in 1950/51 no X1730A seed was taken from there for sowing in the Gezira in 1951-52. In its place reserve seed from the Gash 1949-50 crop, augmented by seed picked from selected Gezira blocks reporting negligible blackarm in 1950-51, was sown. The Gash-origin seed was sown in South Group and most of the other X1730A blocks used Gezira-origin seed. Field observations did not indicate that sowing of Gezira-origin seed resulted

in heavier blackarm infection and it was concluded that secondary rather than primary (seed borne) infection was largely responsible for the heavy outbreaks of blackarm which occurred in parts of the Gezira this season.

The season was very favourable for development and spread of blackarm disease in the Gezira. Among the factors responsible for this were (1) The very heavy 1950-51 Gezira crop which resulted in a prolonged picking period and insufficient time for really thorough destruction of the abnormally large amount of cotton trash left on the fields. Also blackarm, although not serious, was more widespread in the 1950-51 Gezira cotton fields than for several seasons past. As a result of this poor clean up of the Gezira more cotton trash than usual remained on the fields as a potential source of blackarm infection for the new crop. (2) Climatic conditions: in many parts of the Gezira the rains were late and continued well into September, thus providing favourable conditions for rapid spread of blackarm. Lack of pre-sowing rain combined with heavy and frequent showers during and after sowing caused large numbers of self-sown cotton seedlings to spring up at a time when cultivators were too busy sowing and weeding the new crop to be able to destroy them. Furthermore such seedlings were in many cases hidden in profuse weed growth; no doubt some of them bore blackarm infestation which was later carried by rain and wind into the newly sown fields. The cold weather with accompanying early morning dews of the early winter tended to delay drying out of the disease in parts of the Gezira and thus kept the disease in an active state for longer than usual.

In the Gezira some of the new cotton fields are immediately adjacent to those of the previous season and blackarm commonly spreads from the latter to the former. It was urged that the rotation be altered to ensure that new and old cotton fields are as far apart as possible or — if this is considered impracticable — that new fields adjacent to old ones be sown later than usual. Young BAR. X1730L.1 cotton was severely attacked by blackarm in parts of the Gezira but most of the plants later made good recovery and were not nearly as seriously damaged as the susceptible X1730A commercial strain.

Some alarm was felt over the widespread incidence of blackarm disease in newly irrigated areas of the Gezira (the North West Extension) in which cotton had not previously been cultivated. The sources of infection were probably in part wind-blown infected cotton trash and — to a greater degree — cotton sticks, bolls, seeds etc. brought into the area by tenants and others for burning and private home spinning. It is known that such transference of cotton, although illegal, occurs throughout the Gezira. Similar outbreaks of blackarm in areas not previously cropped with cotton have been investigated in the past and in almost all cases have been traced to this unauthorised transport of cotton products. It is to be expected that the disease will appear in all newly opened parts of the Gezira where cotton is to be grown. This season it was unfortunate that climatic conditions encouraged extensive spread in the first season of cultivation,

2. Leaf Curl (*cotton leaf curl virus*).

Leaf curl disease was widespread on Sakel cotton in the northern Gezira and must have caused considerably greater loss of crop than for several seasons past. It appeared earlier than usual and some areas were severely infected. The disease was slight in 1950-51 but heavier than in 1949-50 and the poor clean up and late rains during 1952 encouraged more extensive ratoon growth than usual. The whitefly vectors of leaf curl were very abundant this season and ensured rapid dissemination of the disease.

3. Other diseases of cotton.

Wilting of cotton plants was extensive in the central and southern Gezira. Occasionally it appeared to be fungal in origin but in most cases it was associated with extremely heavy infestation of the plants by whitefly leading to extensive leaf shedding and withering. Insect asal (honey dew) was very prevalent and in some cases carried a growth of sooty mould fungi (mostly *Cladosporium*, some *Alternaria* and others). Boll rot (various causes) was occasionally observed. Purple spotting of leaves and bolls was widespread in places; this appears to be a non-parasitic disorder since no micro-organism likely to cause the spotting was observed upon examination of affected leaves — the spots appear to consist of patches of pigmented tissue.

B. DURA (*Sorghum vulgare*, Pers.).

Covered smut (*Sphacelotheca sorghi*, (Link) Clint.) was noticed in places where untreated seed had been sown. Loose smut (*S. cruenta*, (Kuehn) Potter) was occasionally noted.

C. LUBIA (*Dolichos lablab*, L.).

Bacterial blight (*Xanthomonas phaseoli*, (E. F. Sm.) Dowson) was often severe on early sown lubia in areas where late rains encouraged its spread. Lubia sown after the rains suffered negligible damage. *Macrophomina* wilt (*M. phaseoli*, (Maubl.) Ashby) was occasionally severe in small scattered areas and was often associated with termite damage. Mosaic, a suspected but uninvestigated virus disease, was occasionally seen on lubia in the Gezira.

D. OTHER CROPS.

Tomato leaf curl (a suspected virus disease) was widespread as was cotton leaf curl on bamia (*Hibiscus esculentus*, L.). Powdery mildews (including *Leveillula taurica*, (Lév.) Arn. and *Sphaerotheca fuliginea*, (Schlecht.) Poll.) on bamia, cucurbits and other vegetables appeared to be later in appearance and lighter in incidence than usual — due, perhaps, to the cold spells of weather during the winter months.

II. PLANT DISEASES AT THE GEZIRA RESEARCH FARM

A. COTTON.

1. *Blackarm.*

This disease was general throughout G.R.F. cotton this season and was responsible for considerable damage in some plots. The first infected seedlings were observed in plots 2, 3 and 4 in early September, some two weeks earlier than in 1949 and 1950. A few self-sown seedlings with blackarm symptoms were found in plot 2 at the same time and it is likely that the disease spread from such seedlings and infected trash in these plots to the newly sown adjacent cotton. The late rains brought up large numbers of self-sown cotton seedlings in late August, throughout September and well into October. Special efforts were made to destroy them but they came up in very large numbers and at a time when all available labour was employed in sowing and weeding — consequently many survived and provided sources of infection for the 1951-52 crop. Blackarm infected self-sown seedlings were found and destroyed during September and early October but no doubt many were not destroyed. Late rains spread the disease rapidly and infection was evident in most G.R.F. cotton plots in the second half of September. Stem lesions leading to breaking and death of the tops of plants were evident in many plots and all in all blackarm must have caused more damage this season at the G.R.F. than for several years past. Observations on the disease in certain G.R.F. standard plots in late October 1951 indicated that the attack was considerably heavier in these plots than for the previous four seasons at least.

2. *Leaf Curl.*

Leaf curl was first observed in early October in Plot 57, more than three weeks earlier than in the previous season. Thereafter the disease spread quickly and most Sakel plots showed considerable infection at the end of theseason. Observations made on certain G.R.F. Sakel plots in the first half of March 1952 indicated that the percentage infection was higher than for several seasons past — varying between 45 and 70 per cent. Fair numbers of ratoons appeared during late August, September and early October on 1950-51 G.R.F. cotton plots. They were more numerous than usual and some were leaf curl infected. As many as possible were destroyed but no doubt they constituted the main source of infection for the 1951-52 crop. Heavy infestations of whitefly ensured rapid spread of the disease with the result that some plots suffered considerable damage.

3. *Other diseases of cotton.*

Sooty mould (*Cladosporium*, *Alternaria* and other fungi) on the asal excreted by whitefly was observed as were also fungal wilt (occasional) and wilting apparently caused by extremely heavy infestation of the foliage by whitefly.

B. DURA.

Occasional cases of covered smut and loose smut were observed but neither disease was of importance. Leaf spotting (*Colletotrichum graminicola*, (Ces.) Wils.) of young dura occurred to a slight extent.

C. LUBIA.

Bacterial blight was severe on some early sown plots but negligible on winter lubia. *Macrophomina* wilt was widespread on young lubia, usually associated with damage by termites or other pests to the roots or hypocotyls. Mosaic (a suspected virus disease) was noted in some plots.

D. OTHER CROPS.

Several diseases on leguminous crops in experimental plots were observed. These include leaf spotting (*Phyllosticta* spp.) of velvet bean (*Mucuna* sp.), lubia (*D. lablab*, L. ECR 923), cowpea (*Vigna unguiculata*, (L.) Walp.) and "Babun" bean (*V. vexillata*, Benth.). Leaf spotting caused by *Ascochyta phaseolorum*, Sacc. was present on *Phaseolus trilobus* and on green gram (*Phaseolus mungo*, L.) and a leaf spotting associated with *Macrophomina phaseoli*, (Maubl.) Ashby was observed on black gram (*Phaseolus mungo*, L. var. *radiatus*). Suspected bacterial diseases were observed on soya (*Glycine max*, (L.) Merr.) black gram, green gram and (doubtfully) on *P. trilobus*. Typical virus disease symptoms were noticed on black and green grams. Little is known of these diseases and they may become of importance if large scale cultivation of these legumes is ever practised.

Tomato leaf curl (suspected virus disease) was widespread and destructive. Cotton leaf curl caused considerable damage to bamia. Powdery mildews on bamia, cucurbits and other vegetables were late in appearing this season and were less severe than usual.

III. PLANT DISEASES IN OTHER PARTS OF THE SUDAN

A. THE GASH DELTA.

Observations on seasonal carry-over of cotton diseases in the Gash Delta were made in late September 1951. Ratoon growth in general was much less than in previous years. This is to be attributed largely to the below-average rainfall in the Gash Delta during the 1951-52 season and, in the case of Sakel areas, to a high standard of pulling out of cotton plants at the end of the season. About two Sakel ratoons per acre were found in September 1951 as compared with about sixteen and sixty-six Sakel ratoons per acre in 1950 and 1947. Some sixty per cent of the Sakel ratoons showed severe leaf curl symptoms, associated with the heavy leaf curl which had occurred in much of the Sakel in 1950-51. Growth of self-sown cotton seedlings was slight and none with blackarm symptoms was seen although this disease was observed on ratoon X1730A growing in fields known to have been severely attacked in the 1950-51 season.

An inspection of 1951-52 Gash cotton fields was carried out during November — December 1951. The incidence of blackarm disease was much lighter than in the previous season, when heavy late rains caused a severe blackarm attack on early sown cotton, but was nevertheless somewhat heavier and more widespread than usual. No doubt much infected cotton trash remained after the 1950-51 crop and it was fortunate that the abnormally low rainfall in 1951 did not encourage extensive spread of the disease. Only in a few fields was blackarm anything more than light this season and 1951-52 Gash seed was probably only very slightly contaminated.

Leaf curl disease was widespread in Sakel areas, particularly in early sown Sakel. A few patches of heavy infection were observed but leaf curl was in general light to medium this season. Occasional small plots of infected bamia were seen.

B. TOKAR.

Blackarm disease was present on Tokar cotton at the end of 1951, its development and spread being encouraged by abnormally heavy and early rains. It quickly dried out when the rains ceased and caused little damage. This is the first time for many years that blackarm has been noticeable in Tokar cotton.

C. CENTRAL RAINLANDS.

BAR. SP84 cotton at Um Sugura Mechanised Crop Production Scheme was inspected in late September 1951. Blackarm was widespread and in many plots severe; numerous dried up, blackened and dying plants were observed. The infection was largely seed-borne. The seed was from the previous season's Nuba Mountains crop and had not been disinfected. Later in the season the disease dried out after having been responsible for heavy damage in some plots. This severe outbreak can be attributed to the sowing of untreated, contaminated seed and the advent of heavy postsowing rains which favoured development and spread of the disease. It was recommended that BAR. SP84 seed sown in the central rainlands should be treated with Abavit B before sowing in order to destroy seed borne infection present.

D. EQUATORIA.

A tour of forest reserves and nurseries in the Katire — Juba — Loka West area was made with the Forest Entomologist. A report on this was submitted and much information concerning the crop diseases present in the area was collected.

E. UPPER NILE PROVINCE.

Experimental crops under cultivation at the Malakal Experimental Farm were inspected and a report on diseases noted was prepared.

IV. EXPERIMENTAL WORK

BLACKARM DISEASE OF COTTON.

Disinfection of cotton seed against X. malvacearum.

Research on methods of destroying seed-borne blackarm disease was continued. Several recently formulated organo-mercurial seed dressings gave at least as good control as Abavit B (the standard dressing used in the Gezira) in field trials. Granosan M and R1489, an experimental dressing supplied by Messrs. Imperial Chemical Industries Ltd., gave significantly better control than Abavit B in plot trials at the G.R.F. Larger scale trials will be carried out in the 1952-53 season. The application of R1489 as a slurry treatment was investigated and gave promising results provided that very rapid and thorough mixing of slurry liquid and seed is accomplished and that an application rate of slurry/seed of about 5 per cent is employed. With rapid and thorough mixing this relatively high application rate produces fairly evenly damped seed which could probably be safely put into sacks without further drying. Several non-mercurial substances much less poisonous than Abavit B were tested but none was as effective as the latter. The use of water steeping as a method of destroying seedborne *X. malvacearum* was investigated but so far it has not been possible to do this effectively without adversely affecting the germinating power of the seed. A study in the factors concerned in the latter process was made and experiments investigating the toxicity of inorganic mercurial salt to cotton seed were concluded.

Detailed data of the work outlined above are not given here since it is hoped to have them published in the Empire Cotton Growing Review early in 1953.

Observations on blackarm disease in the Gezira.

Due to severe blackarm in some of the early sown X1730A cotton of the 1950-51 Gash Delta cotton crop Gezira-origin seed was sown in parts of the Gezira in 1951-52. This seed was carefully selected from areas in which blackarm had been negligible and was ginned and treated with Abavit in the normal way. Estimates of blackarm severity were carried out in Abdel Hakim, Radma, Seleimi, Tebub and Barakat blocks in early October and early November 1951; as far as possible adjacent areas sown with Gash-origin and Gezira-origin seed were compared. The Gash-origin seed was that from the X1730A crop of 1949/50.

The results obtained indicated that the sowing of Gezira-origin seed did not lead to heavier blackarm infection. The very light blackarm in some of the fields sown with Gezira-origin seed suggested that the latter could not have been more than slightly contaminated. It must be noted however that the Gezira-origin seed had been carefully picked from fields known to have been almost free from blackarm disease and a very different result would probably be obtained were sowing seed to be taken indiscriminately from the general Gezira crop. It was concluded that the sources of blackarm infection for the severe outbreaks which occurred in parts of the Gezira in 1951-52 were secondary

rather than primary; this is discussed in the first pages of this report. These observations also emphasised the importance of sowing date with respect to subsequent blackarm incidence; the earlier sown fields showed much more infection than those sown a few days later.

Sowing date and blackarm incidence at the Barakat Seed Farm.

Estimates of blackarm incidence were made in a field of cotton in which pairs of angaias had been sown at two-day intervals during the period 22nd. August — 2nd. September. It was found that both the number of infected plants and the blackarm severity lessened markedly with increasing lateness of sowing. Thus the earliest sown cotton (22nd. August) showed about 60 per cent infection (severity 13.5 points) whilst that sown four to six days later showed about 30 per cent infection (severity 7-11 points) and that sown on 1-2 September showed only about 10 per cent infection (severity 6 points). The importance of delayed sowing in areas where heavy blackarm attack may be expected is apparent, *e.g.* in places where new cotton fields are adjacent to those of the previous season or in areas which had suffered severe blackarm outbreaks in the previous season.

LEAF CURL DISEASE OF COTTON.

End of season destruction of cotton plants.

This investigation into possible methods of destroying cotton plants by means other than the expensive and laborious hand-pulling at present employed in the Gezira and elsewhere was continued. Previous work had shown that spraying the plants in situ with certain hormone weed-killers did not afford a sufficient degree of destruction. This season the plants were cut just above ground level and the cut ends were thoroughly wetted with cotton wool soaked in various solutions. Observations on ratoon ground during the following rains were made. 50.35 per cent of the control (untreated) plants sprouted, the figures for the treated plants being 37.41 per cent (5 per cent sodium chlorate solution), 2.65 per cent (1 per cent chloroxone) and 2.41 per cent (1 per cent methoxone). Although treatment with the two hormone weed-killers reduced the number of ratoons from approximately 50 per cent to $2\frac{1}{2}$ per cent this degree of mortality is not high enough for the Gezira where there may be some twenty thousand cotton plants per acre — even if only 1 per cent sprouted there would be about 200 ratoons per acre, a much heavier growth than occurs with the present method of hand pulling. This work will be continued.

COVERED SMUT AND SEED DRESSINGS FOR DURA (SORGHUM).

Plot experiments to test the relative effectiveness of various seed dressings in the control of covered smut (*Sphacelotheca sorghi*) and improvement of emergence were carried out. With irrigated dura at the G.R.F. TMTD dressings, Spergon, Phygon and Mergamma (organo-mercurial) gave somewhat better smut control at the application rate of 1:500 to seed than copper carbonate at 1:300, the standard sorghum seed dressing at present used in the Sudan. The effectiveness of TMTD dressings in smut control was not adversely affected by

addition of 40 per cent gamma BHC. Markedly improved seedling emergence was observed with seed which had been treated with these combined fungicide — insecticide dressings as compared with that treated with fungicide alone. Conditions for germination and seedling growth were somewhat unfavourable and presumably the gamma BHC in the dressings protected the seed from soil pests.

Similar results were obtained with rain-grown dura in an experimental plot at Gihadamaliya Mechanised Crop Production Scheme. Seed which had been dusted with mixed gamma BHC — TMTD dressings produced much better stands than that dusted with TMTD only. Further work on this will be carried out and it is hoped to arrange a larger trial next season.

In a small experiment in which spores of covered smut were mixed with dura seed at various application rates it was found that about 7 per cent smutted heads resulted from application rates of 1:100 and 1:1000 of smut/seed, 4.5 per cent from 1:10,000 and even at the low rates of 1:100,000 some 1.7 per cent smutted heads were recorded. It appears that even slightly contaminated seed can, if not treated with seed dressing, result in appreciable smut infection.

SEED DRESSINGS FOR GROUNDNUTS.

A small preliminary experiment was carried out with machine sown groundnuts on the Kordofan sands at Sungikai. It was found that seed treatment at the application rate of 1:400 of dressing to seed by weight with Agrosan GN (organo-mercurial), 50 per cent TMTD and 25 per cent TMTD resulted in improved stands and increased yields. In the case of Agrosan GN emergence was greater by about 50 per cent as compared with untreated seed and yield of the former was about 40 per cent greater than that of the latter. Increases with the TMTD dressings were of about the same order. This work will be extended to the Gezira in the coming season.

V. GENERAL

Many specimens of plant diseases sent in from all over the Sudan were indentified and advice given upon their control.

Among the many specimens collected during the season were:—

Alternaria brassicae, (Berk.) Sacc. causing quite severe leaf spotting of turnip at Iwatoka (Equatoria). This fungus has not previously been recorded in the Sudan.

A. brassicicola, (Schwein.) Wilts. on radish.

Leaf spot, not previously recorded on this host in the Sudan.

A. citri, Pierce on various citrus (lime, sweet orange and lemon) at Wad Medani, Sennar and Ban Gedid (Kordofan). Causing severe leaf blotch, not previously recorded in the Sudan.

Ascochyta phaseolorum, Sacc. causing leaf spotting of legumes — on haricot bean at Katire, on green gram and *Phaseolus trilobus* at Wad Medani.

A. sorghina, Sacc. causing leaf spotting of dura at Malakal.

Cercospora canescens, Ell. & Mart. causing severe leaf spotting of earth-nut (*Voandzeia subterranea*, Thou.) at Gumbiri (Equatoria) and Malakal.

C. cucurbitae, Ell & Ev. causing leaf spotting of loofah (*Luffa cylindrica*, M. Roem.) and sweet melon at Wad Medani. Not hitherto recorded as far north as the Gezira.

Helminthosporium torulosum, (Syd.) Ashby on banana at Juba. Not previously recorded in the Sudan; causing quite severe leaf spotting.

Melampsorella ricini, (Biv-Bern.) de Toni. Rust of castor. From Iwatoka (Equatoria). Castor rust has not previously been recorded in the Sudan.

Microxyphium sp. on robusta coffee in Yei River District and at Gilo (Equatoria). A dense black mould on leaves, stems and berries, associated with heavy insect infestation.

Mycosphaerella fragariae, (Tul.) Lind. causing quite severe leaf spotting of strawberry at Iwatoka. Conidial stage (*Ramularia tulasnei*) only.

Puccinia helianthi, Schw. on sunflower at Malakal. Sunflower rust might well become serious if intensive cultivation of this crop were ever started in the wetter areas of the Sudan.

P. sorghi, Schw. on maize at Katire and Gumbiri. Although not hitherto recorded in the Sudan this rust disease is probably widespread in Equatoria; it appears to cause only minor damage at present.

Scoletotrichum musae, Zimm. (= *Cordana musae*, Zimm.) (Hohnel) on banana. Collected at Bor (Upper Nile Province) and causing extensive leaf blotching. This disease can cause severe damage to bananas in some countries and has not previously been found in the Sudan.

COTTON BREEDING SECTION

The Gezira Station

R. L. Knight, M. F. Rose, and L. C. Hughes.

METEOROLOGY.

Pre-sowing rains were very light, the rainfall return for the period July 1st. — August 15th being only 48.7 mm. a record low. This compares very unfavourably with the normal of 218.3 mm.. The yearly total amounted to only 236 mm. (an all-time low) against a mean B_2 and B_3 and with fair resistance to leaf curl.

Experimental plots were spared from 'untimely' rain on the emerging crop and initial stands generally were good. Just before the flowering phase, however, growth was arrested and the crop then suffered the same sequence of set-backs as the central Gezira crop. Bad boll opening was much in evidence, caused possibly by low November — December temperatures imposed on an already debilitated plant.

BREEDING.

The breeding material, planted on August 11th. and 12th. in Plots 28 and 29 respectively, covered an effective area of 5.9 acres. Only material carried over to the 1952-53 season is listed below :
EGYPTIAN (S. TYPE).

* BLR. 14/25. *A Sakel type carrying the blackarm resistance genes B_2 and B_3 and with fair resistance to leaf curl.*

1452 single plants were grown as progeny rows with Domains Sakel (commercial bulk) and BLR. 14/25 (parental bulk) as local controls. Progeny rows were adequately sampled, examined and 'filtered' as progeny rows : 235 of these were eventually bulked to give the nucleus BLR. 14/25. 1. The end point is a type with lint characters equal to but not superior to those of Domains Sakel. Ginning out-turn (in extreme cases 2.3 per cent below that of Sakel) must be raised and maintained at Sakel level to satisfy commercial requirements. Thus in the filter, ginning out-turn was given first priority. Comparable data from the breeding plot are shown below :—

BLR. 14/25.1 = 29.7 per cent. BLR. 14/25 = 29.0 per cent.
DS = 30.0 per cent.

The leaf curl resistance of the nucleus will be increased still further at Shambat in the early 1952-53 season.

* A glossary explaining the meaning of these symbols will be found at the end of the 1950/51 Annual Report.

EGYPTIAN (L TYPE).

BAR. 4/16. — An X1730A type carrying B_2 and B_3 .

830 single plants from a self-bred bulk of BAR. 4/16 were inspected daily and, as soon as possible after individual boll formation (approximately 2-3 days after flowering), these were cut and seeds per loculus determined. Sampling and selfing continued on all plants throughout the season. Frequency distributions indicated a range of 5.65 — 7.70 seeds per loculus, with a mode at 6.60. Plants below the mode were discarded, leaving 464 plants for individual attention during the coming season.

The object of this work is two-fold (i) primarily to increase the yield of BAR. 4/16, (ii) to give a cleaner and more healthy boll opening. Under Gezira conditions bad opening (to which BAR. 4/16 is prone) is usually associated with a low number of seeds per boll.

BAR. 4/16 — 664. Selected from BAR. 4/16 by Anson for improved length and fineness.

A small special bulk, derived from a single progeny row, again showed this superiority. After hand stapling, 68 plants were retained for more detailed examination in the coming season.

BAR. 5/6. An X1730A type carrying B_2 and B_3 ; also the red pigment gene R_2 RS.

992 typical plants from a bulk of pure-bred seed were selfed: 106 were eventually retained as single plant selections after all had been measured for length and tested for strength and fineness.

The following points in favour of BAR. 5/6, possibly a successor type to BAR. 4/16, are noted. (i) it gave alea count $\times$ strength product (80's) superior both to BAR. 1730L. 1 and BAR. 4/16 during the very bad season of 1951-52, (ii) also a superior yarn appearance, (iii) the presence of a 'marker' gene in one of the two commercial types would facilitate rogueing operations.

BAR. 1730L. 1. An X1730A type carrying B_2 .

$\frac{1}{4}$ acre was rogued and selfed for type maintenance.

XAT. 1. A 1730A type derived from 200 single plants selected and bulked by Knight from the 1950-51 Tokar crop.

This special bulk is one of two distinct components in the commercial Tokar crop, capable of retaining the bolls on its lower sympodia under conditions of shade (cloud). It will be tested against the commercial bulk in a variety trial at Tokar during the coming season.

AMERICAN IRRIGATED.

Wilds SUS. 16/1 and Wilds SUS. 16/1 (naked seed).

A big balled, long staple cotton grown under irrigation: this type has been selected for increased earliness. 0.25 acres were grown as a selfed bulk,

An attempt is being made to acclimatize this type to central Gezira conditions. Under the general conditions of poor yield and bad opening prevalent this season, Wilds SUS. 16/1 gave lint of good quality at the rate of 439 lbs per acre. In terms of yield, ginning out-turn and seed characters there were no indications that the 'naked' component had any deleterious effect on the commercial crop.

AMERICAN RAIN-GROWN.

BAR. NT 96 'cluster' type.

An original single plant selected in 1950/51 for dwarf habit, cluster-boll and shortened sympodia.

With the advent of mechanized crop production in the central rainlands the development of this type is of special significance. Unfortunately the 'cluster habit' appears to be linked with marked physiological shedding.

BREEDING. SPECIAL PROBLEMS.

Salt Tolerance. Soil alkalinity in various parts of the Sudan is known to affect both yield and quality. The production of strains within the various BAR lines tolerant of such conditions would be a step forward of major importance. To this end and in co-operation with the Soil Research Section work was begun on the tolerance of the cotton seedling to varying quantities and qualities of salt.

'Stormproof' Sakel Derivatives. In seasons of heavy yield and during periods of high wind with picking periods curtailed by the watering interval, much seed cotton can be blown to the ground and lost in the irrigation water. In this respect commercial losses over a period of years must be high. To remedy this, an attempt is being made to transfer the 'stormproof' character of *G. contextum* to Sakel derivatives. The nature of this 'lint retention' in *contextum* and its mode of transference is also being studied.

TESTING.

The standard variety trials were laid down in the northern (Turabi), central (G.R.F.) and southern Gezira (Hag Abdalla) on the 13th., 13th and 17th August respectively. The layout was identical:—randomized blocks of 12 varieties x 10 replications of plot size 0.0266 acres spacing 80 cms x 35 cms. Relevant data are shown in Table 1.

Table 1.
GEZIRA VARIETY TRIALS 1951-52.
YIELDS OF SEED COTTON AND LINT POUNDS PER ACRE

Variety	BAR Genes	Turabi (North)		G.R.F.(Centre)		Hag Abdalla (South)	
		Seed Cotton	Lint	Seed Cotton	Lint	Seed Cotton	Lint
Domains Sakel ...	—	1471	462	380	132	342	104
BLR. 14/25 (Shambat)	B ₂ B ₃	1547	455	967	301	904	263
BLR. 14/16 (Gash)	B ₂	1331	382	852	259	861	247
BLR. 14/16 (G.R.F.)	B ₂	1383	398	928	286	885	250
BLR. 14/16 (G.R.F.)	B ₂	1274	371	889	273	869	248
X1730A (Gash) ...	—	1522	526	624	220	632	218
BAR. 1730L (Gash)	B ₂	1443	492	942	330	1165	390
BAR. 1730L.1 (Gash)	B ₂	1458	502	934	326	1102	378
BAR. 1730L.1 (G.R.F)	B ₂	1441	500	948	324	1100	373
BAR. 1730L.3 (G.R.F)	B ₂	1446	500	816	288	1108	370
BAR. 4/16 (Gash) ...	B ₂ B ₃	1351	439	914	305	1090	349
BAR. 4/16.1 (G.R.F.)	B ₂ B ₃	—	—	800	270	—	—
American Type							
BAR. NT 96. ...	B ₂	1315	466	—	—	383	135
S.E. =			13.8		17.2		8.0
Difference P= 0.05			39		48		22

N.B. American type BAR NT 96 excluded from statistical analyses.

The points of interest in Table 1 are:—

- (i) in the absence of blackarm (Turabi), BLR 14/25 has indicated a yield potential equal to that of Domains Sakel.
- (ii) in cases of severe infection (G.R.F. and Hag Abdalla) it has outyielded Domains Sakel by 128 per cent and 153 per cent respectively (lint values).
- (iii) in the absence of blackarm (Turabi) lint yields from X1730A have not outyielded significantly those of the BAR (B₂) types derived from it.
- (iv) in the presence of severe blackarm (G.R.F. and Hag Abdalla) the mean lint value from the BAR derivatives has exceeded that of X1730A by 44 per cent and 73 per cent respectively. Such data offer convincing evidence of the value of the genes B₂ and B₃ under conditions of severe blackarm infection.
- (v) at each of the 3 sites, there is no evidence that the seed of BAR types of Gash origin is superior in yield potential to that of the Gezira.

The present season's yield figures (Table 1) are incorporated in Table 2: spinning test data for last season (1950-51) in Table 3,

Table 2.
SUMMARY OF PERFORMANCE OF CURRENT STRAINS IN GEZIRA VARIETY TRIALS.
(UP TO AND INCLUDING SEASON 1951-52).

VARIETY	* Basic Type	No. of Trials	SEED COTTON (lbs./acre)				LINT (lbs./acre)				LOCATION			
			MEAN		Variety as % of		MEAN		Variety as % of					
			Variety	Dom Sakel	XI730A	Dom, Sakel	Variety	XI730A	Dom, Sakel	XI730A		Dom, Sakel		
Domains Sakel } BLR. 14/16 } BLR. 14/16.1 } BLR. 14/25 } XI730A ... } BAR. 1730L. } BAR. 1730L.1 } BAR. 1730L.3 } BAR. 4/16 } BAR. NT. 96 }	S	13	1257	1312	1257	96	100	13	402	456	402	88	100	NORTHERN GEZIRA
		3	1625	1795	1785	91	91	3	482	639	574	75	84	
		1	1274	1522	1471	84	87	1	371	526	462	71	80	
		1	1547	1522	1471	102	105	1	455	526	462	87	98	
		13	1312	1257	1257	100	104	13	456	462	402	100	113	
		12	1295	1349	1303	96	99	12	463	469	419	99	111	
		8	1272	1351	1308	94	97	8	448	478	421	94	106	
		1	1446	1522	1471	95	98	1	500	526	462	95	108	
		4	1696	1905	1940	89	87	4	573	687	632	83	91	
		1	1315	1522	1471	86	89	1	466	526	462	89	101	
Domains Sakel } BLR. 14/16 } BLR. 14/16.1 } BLR. 14/25 } XI730A ... } BAR. 1730A } BAR. 1730L.1 } BAR. 1730L.3 } BAR. 4/16 } BAR. 4/16.1 }	S	26	1540	1827	1540	84	100	26	487	643	487	76	100	CENTRAL GEZIRA
		4	1314	1155	866	114	152	4	401	421	293	95	137	
		1	889	624	380	142	234	1	273	220	132	124	207	
		1	967	624	380	155	254	1	301	220	132	137	228	
		26	1827	1827	1540	100	119	26	643	643	464	100	133	
		14	1694	1682	1452	101	117	14	619	597	464	104	133	
		9	1630	1500	1204	109	135	9	575	537	386	107	149	
		1	816	624	380	131	215	1	288	220	132	131	218	
		5	1727	1556	1195	111	145	5	596	569	402	105	148	
		1	800	624	380	128	211	1	270	220	132	123	205	
Domains Sakel } BLR. 14/16 } BLR. 14/16.1 } BLR. 14/25 } XI730A ... } BAR. 1730L } BAR. 1730L.1 } BAR. 1730L.3 } BAR. 4/16 } BAR. NT. 96 }	S	9	1306	1466	1306	89	100	9	419	521	419	80	100	SOUTHERN GEZIRA
		3	1146	999	858	115	134	3	340	356	281	96	121	
		1	869	632	342	138	254	1	248	218	281	114	238	
		1	904	632	342	143	264	1	263	218	104	121	253	
		9	1466	1466	1306	100	112	9	521	521	419	100	124	
		9	1530	1466	1306	104	117	9	551	521	419	106	132	
		8	1401	1257	1019	111	137	8	491	442	331	111	148	
		1	1108	632	342	175	324	1	370	218	104	170	356	
		4	1371	1273	1185	108	116	4	450	454	391	99	115	
		1	383	632	342	61	112	1	135	218	104	62	130	

* S = Sakel Group.

L = 1730 Group.

Shambat Station. METEOROLOGY

Rains started in May and totalled 80 mm. nearly all of this falling in late July and August. Summer temperatures were not unduly high, and the winter was abnormally cold, temperatures down to 8.3°C being recorded. This cold and prolonged winter, coupled with a very heavy whitefly infestation, affected the out-of-season breeding plots so severely that many families failed to give any seed. During the period 1st. May 1951 to 30th. April 1952 there were 216 days when the shade temperature registered 38°C or over, 36 days with 43° or more and no days with 46° or over. These figures compare with averages for the previous nine seasons of 202, 33 and 2 days respectively.

ECONOMIC GENETICS

by R. L. Knight and J. Sadd.

PRODUCTION OF "EGYPTIAN" VARIETIES RESISTANT TO BLACKARM AND LEAF CURL.

DOMAINS SAKEL DERIVATIVES.

BLR. 14/25 ($B_2 B_3 + \text{leaf curl resistance}$).

The first wave of BLR. 14/25 made at Shambat last season was considered to be "almost immune to blackarm but only moderately resistant to leaf curl". Seed of this material was included in the three Gezira variety tests this season and its blackarm immunity was adequately demonstrated at G.R.F. and Hag Abdalla — there was no appreciable blackarm at Turabi.

The relative leaf curl resistance of BLR. 14/25 and Domains Sakel was estimated by a detailed examination of the cut-back guard rows at the G.R.F. variety test. The following results were obtained. Leaf curl grading of BLR. 14/25 and Domains Sakel (percentages).

Leaf curl grade.						
	' 0 '	' 1 '	' 2 '	' 3 '	' 4 '	Total
D.S. 	10.5	14.2	31.2	39.8	4.3	100.0
BLR. 14/25 	22.6	12.2	30.6	33.1	1.5	100.0

These figures are based on ten replications totalling some 3,500 plants in each variety. Obviously BLR. 14/25 itself shows little leaf curl resistance,

BLR. 14/25.1

Seed of the 1567 single plants, left after leaf curl roguing in BLR. 14/25, was filtered at Medani and 235 successful progenies were bulked as BLR. 14/25.1. Self-bred seed of this substrain was sown at Shambat, on 19.3.52, on two acres at one seed per hole. At sowing time 400 cut-back leaf curl-infected plants were transplanted within the two acres and one acre of lubia was sown alongside to build up the population of whitefly which carry the disease. These two acres of BLR. 14/25.1 will be rogued regularly for leaf curl, and plants which remain free from the disease at the end of the season will be bulked as BLR. 14/25.2.

BLJR. 14/29 ($B_2 B_3 H_1$ + leaf curl resistance).

This season a strain of Domains Sakel homozygous for $B_2 B_3$ and H_1 was synthesised from a cross between BLJR. 14/23 and BLR. 14/25. This was rogued for leaf curl in an in-season propagation plot and the product of this plot was sown out-of-season and again rogued for leaf curl.

This strain is intended solely for use as the final backcross parent in synthesising jassid resistant strains.

OTHER BLACKARM RESISTANCE TRANSFERENCES TO SAKEL AND X1730.

The transference of B_{6m} to $B_2 B_3$ Sakel and $B_2 B_3$ 1730 was continued.

The genes B_5 and B_7 were taken respectively to the sixth and fifth backcrosses to Sakel.

The sixth backcross of B_5 to X1730 was also grown.

The *herbaceum* resistance gene was carried to the sixth Sakel backcross and seed for sowing the seventh backcross was obtained.

PRODUCTION OF BLACKARM RESISTANT STRAINS OF AMERICAN UPLAND.
BAR. 12/9.3.

To increase blackarm resistance by building up a minor gene complex around B_2 in Uganda BP 52, roguing of BAR. 12/9.1 was continued to obtain maximum resistance.

A comparison of BAR. 12/9 with BAR. 12/9.1 showed a slight increase of resistance in the latter :

Comparative blackarm resistance of BAR. 12/9 and BAR. 12/9.1
(Percentages)

			Blackarm grade.					Totals
			' 3 '	' 4 '	' 5 '	' 6 '	' 7 '	
BAR. 12/9	...	...	0.00	0.33	69.66	30.00	0.00	99.99
BAR. 12/9.1	...	...	0.06	3.49	72.72	23.66	0.06	99.99

These figures are based, in the case of BAR. 12/9 on 297 plants and on 4928 plants of BAR. 12/9.1.

The grade '3' and '4' plants were bulked as BAR. 12/9.2. This was grown out-of-season and again rogued for maximum resistance, the product being bulked as BAR. 12/9.3.

The improvement of BAR. 12/9.1 over BAR. 12/9 is so slight that it suggests that the variability of this variety is insufficient to enable high resistance to be built up by repeated selection.

A start was made in transferring B_{6m} to BAR. 12/9.2.

BAR. 7,8.1 ($B_2 B_3$ BAR. SP84).

One tenth of a pound of self-bred seed of BAR. 7/8.1 from Kadugli, was sown on 1/8th acre at Wadi Seidna on 3.5.51. The product of this was used to resow a two acre isolated plot at Semeiha which had been sown with Kadugli seed but which, owing to low seed rate, thrips and poor flowing of the Khor Abu Habl, had only a 10 per cent stand. Seed from Wadi Seidna was also used to sow a 4 acre propagation plot at Shambat on 29.9.51, and part of the seed from these 4 acres was used to sow a 12 acre isolated plot in March 1952.

Within the 4-acres of BAR. 7/8.1 sown in September 1951, 850 plants were selected, each with 15 or more green bolls (the modal number of bolls counted on 2000 plants being 15). Laboratory analysis of these 850 plants was directed toward improvement of length, regularity and strength, and on these characters the number was reduced to 194. These will be sent to Kadugli to be grown as progenies next season.

A start was made in transferring B_{6m} to BAR. 7,8.1.

BAR. 11,7 (XA129 + $B_2 B_3$).

Further variety tests designed and carried out by the Senior Research Officer at Yambio, Equatoria, has confirmed that BAR. 11/5 (XA129 carrying B_2) is the most suitable strain for that area. This season a strain homozygous for B_2 and B_3 was made and given the number BAR. 11,7.

MU8b.

Seven acres of MU8b were grown to obtain a bulk of pure seed for any future requirements.

Wilds Selected Early Strain (SUS16/1).

The transference of B_2 to this type was taken over from the cytogeneticists at the 4th. backcross stage; the $B_2 B_3$ transference which had reached the 2nd backcross was found to have lost B_3 and was discontinued. A transference of B_{6m} to backcross material carrying B_2 was started.

BLACKARM CLASSIFICATION OF IMPORTED UPLANDS.

The following 'mechanical picker' types from Gatooma were graded for blackarm attack :—

	Blackarm grade.						
	' 3 '	' 4 '	' 5 '	' 6 '	' 7 '	' 8 '	' 9 ' ' 10 '
BAR. 7/3			45				45
SUS 7/2							
S49106	—	—	3	—	—	—	42
S49107	—	—	1	—	—	—	44
S49108	—	—	41	—	—	—	1
S49114	—	11	26	—	—	—	3
S49118	—	2	1	—	—	9	30
S49121	—	1	8	—	—	2	32
S49125	—	1	3	—	—	3	34
S49127	7	22	12	—	—	—	—

BAR 7/3 : (B₂ control)

SUS 7/2 : (B₂ control)

JASSID RESISTANCE.

In the transference of MU8b hairiness to Sakel, the full MU8b hairiness was recovered in F₂s of 4th backcross type ; the last three crosses having been to H₁H₁ material and the final one having been to H₁ H₁ B₂ B₂ leaf curl resistant type (BLJR. 14/23). These 4th backcross F₂ selections were crossed with BLJR. 14/29 and the F₁s were grown out of season.

In the transference of hairiness from Philippines Ferguson to Sakel the Ferguson hair-length modifiers have been recovered from 6th backcross F₂ material in which the last three backcrosses were to Blackarm resistant Sakel carrying H₁. In the straight transference of Ferguson hairiness, the full hairiness was recovered from the 4th backcross F₂, but the Ferguson H gene is still completely linked with one of the duplicate genes governing chlorophyll deficiency so that, although full hairiness was recovered, such material does not breed true, since although homozygous for the minor hairiness gene-complex it is heterozygous for the Ferguson H.

Genes for hairiness from *arboreum* and *herbaceum* were taken to the 5th and 6th Sakel backcrosses respectively.

The gene controlling hairiness in the Upland type Pubescent T611 was shown to be identical with the *tomentosum* gene, H₂.

Work with hairiness genes from *G. mustelinum*, *G. punctatum*, St. Ignatius and Hairy Giza 36 was continued.

The transference of MU8b hairiness to Wilds SUS 16/1 was taken over from the cytogeneticists at the first backcross F₁ stage.

TRANSFERENCE OF LINT STRENGTH FROM *G. THURBERI* TO SAKEL.

This season, families with high Pressley indexes were crossed with BLR. 14/25 and with BLJR. 14/29 to bring the *thurberi* strength transference into line with the rest of the breeding programme.

BREEDING TO INCREASE YIELD.

Boll locule number. In the transference of increased number of locules from tetraploid *arboreum* (*sanguineum*) to blackarm and leafcurl resistant Sakel, it was confirmed in fifth backcross material, that the increased number of locules was not controlled by a major gene.

Increased locule number from tetraploid *herbaceum* was recovered in the 5th backcross.

The transference of the 4-loculed character from Philippines Ferguson to blackarm and leafcurl resistant Sakel was continued.

In a third Sakel backcross from Stoneville 20, two plants were selected with mean locule number of 3.8 and 3.6 respectively for further backcrossing. The investigation of the genetics of locule number in Upland strains, started last season, was continued.

Ovules per locule. The first backcross, from out-of-season material, failed and backcrossing from the F_1 was repeated. The donor parent being used as a source of numerous ovules per locule is *G. auritum*.

TRANSFERENCE OF SMALL BRACTS AND LINT QUALITY.

G. barbadense (BLR. 14/25) female was crossed with *G. anomalum* (WB1-11) male and the germinating seedlings were doubled with colchicine to make the hexaploid 'anomadense'. This was backcrossed to BLR. 14/25 and 18 seeds, presumably pentaploid, were obtained for sowing next season.

The objective in this line of crossing is to transfer the small bract of *anomalum* to BLR. 14/25 and also to see whether lint quality genes can be transferred from *anomalum*.

With a similar objective, *G. anomalum* was crossed with BAR. 7/8, but attempts to double the seedlings with colchicine failed, all the treated seedlings dying. The triploid plants, however, were successfully backcrossed to BAR. 7/8 and three plants of this parentage are now growing.

BREEDING FOR EARLINESS.

In the progenies of tetraploid *herbaceum* (Wagad 8) backcrossed to blackarm resistant, leafcurl resistant Sakel, a number of plants showing marked earliness were selected. In addition an extremely early *herbaceum*, Tin Sin (HTK5) was doubled with colchicine as a first step in crossing it with New World cottons in an attempt to transfer earliness.

DISEASES AND PESTS.

Pink and Egyptian bollworms were, as usual, severe. An extremely heavy infestation of whitefly occurred in the out-of-season Breeding Plots where leafcurl caused heavy damage.

CYTOGENETICS.

by H. Douwes and R. L. Cuany

CYTOGENETICS.

Relationship between wild and cultivated species.

G. sturtii was crossed with *G. hirsutum* (MU8b) and with *G. barbadense*. Two plants of the former cross are growing and will be treated with colchicine.

The 'thurboreum' x 'arbanomalum' AD.AB hybrid mentioned in last season's report has given a few seeds on backcrossing to the 2 (AB) 'arbanomalum' parent.

Relationships between wild species.

G. stocksii x *G. areysianum* :—Two F_1 plants were grown. They showed fairly complete chromosome pairing, which agrees with the relationship between *G. somalense* and *G. areysianum* as given in last year's report.

Full details as to the cytogenetic relationships of *G. areysianum* have been prepared for publication elsewhere.

Selfed seed was obtained from the F_1 s of *stocksii* x *areysianum*, *stocksii* x *somalense*, *somalense* x *areysianum* and of *anomalum* x *triphyllum* in order to investigate segregation in F_2 s and following generations.

G. gossypoides. Crossing has been resumed this year with *thurberi*, *harknessii* and *klotzschianum* var. *davidsonii* the latter having the only boll, so far, which did not shed after a few days.

G. robinsonii. This has not yet yielded any selfed seed, but six more plants of the original material are now growing. Of 178 seeds of the cross *robinsonii* x *anomalum*, 176 were empty and the other two died shortly after germination. The hybrids of *sturtii* x *robinsonii* have flowered profusely and set a quantity of natural, and some selfed seed. Backcrossing to *sturtii* has also been successful. Chromosome pairing in the F_1 which is intermediate in most characters and markedly heterotic, is almost complete and there is less than 25 per cent of bad pollen. These data indicate that *G. robinsonii* belongs to the C genom.

GENETICS.

Blackarm resistance and B linkage tests.

A further backcross has been made in the process of analysing the gene make-up of blackarm resistant West African and West Indian *punctatum* types. It has been proved that Samaru 26C contains only

one major gene (B_2) and that a weakly resistant component of Nigerian Allen also contains B_2 alone. The F_2 of a cross between Acala UA2-15 ($B_2 B_2 r_1 r_1$) and an Acala Red mutant stock ($b_2 b_2 R_1 R_1$) showed no linkage between B_2 and R_1 .

The transfer of B_2 and B_3 from BAR stocks, and of hairiness from MUBb to SUS 16,1 has been carried a stage further, and handed over to the economic geneticists.

The transference of a number of single gene characters to leaf curl resistant (but blackarm susceptible) *G. barbadense* for linkage testing with the B genes has been continued.

Of the direct crosses between these characters, occurring in blackarm susceptible plants, and the B_2 gene, some F_2 s and backcrosses have been analysed. The gene B_2 was shown to segregate independently of the following characters:—Non-expansive lint (nx), Guatemala khaki lint (lc₁k), Gambia brown lint, Virescent yellow (v), Hairiness (H_1), Red leaf (R_2^{LW}), Crinkled (cr), Super-Okra (L^S), Okra (L^O), Round leaf, Short branch (Sh), Red filaments, Petal spot (R_1), Cream corolla (Y_1^P), Cream pollen (p), Naked seed (ft).

Miscellaneous genes in New World cottons.

The study of curly-rogue in Egyptian cottons has been suspended. Check crosses of the mutant smooth boll gene in local and American-Egyptian cottons were grown out of season but have given no results as yet. The F_1 between *G. hirsutum* race *palmeri* and okra-leaved Upland was grown at Wad Medani to get a larger yield of F_2 seed, which will be sown in 1952.

Asiatic linkage tests.

The linkage study mentioned in last season's report has been suspended due to pressure of other work. The seed has been stored.

Homology of transferred Asiatic genes.

This season 20 F_2 progenies were grown for testing whether the re-transferred red leaf gene R_2 has gone into the same locus as the original transference of R_2 . Only one out of 345 plants was doubtfully simplex for R_2 and that has been selfed as a check. Also two further F_1 progenies have been grown and selfed; the F_2 s will be grown next year as an extra check.

In the testing of the two B_4 transferences, resistant ($B_4 b_4$) plants of the sixth Sakel backcross in the second transference from "sanguineum" were crossed with BAR. 14/19 (first transferred $B_4 B_4$ type).

TYPE COLLECTION.

This year the collection has been increased by one *anomalum* (from Darfur), one *sturtii* (from South Australia), and five specimens of *thurberi* (from Arizona). In addition the stocks of *G. aridum*, which has never flowered in Shambat in six years but grows as a 15 ft tree, and of *G. harknessii*, were augmented by seed from Texas Agricultural and Mechanical College. Thirty-eight samples of *G. tomentosum*, recently collected by Dr. J. A. Rigney, were received.

Maintenance and Surveys.

Except for testing of blackarm resistance, which has to be done at Shambat for safety, and bollworm resistance, future maintenance and analysis of the type collection will be done on the Gezira Research Farm. This alteration in policy will give a great advantage in the maintenance of adequate stocks of self-bred seed, because bollworm is never as severe in the Gezira as it is at Shambat.

A four year plan has been made out for the analysis of economic characters in the 1,200 strains of linted cottons, and this year a 'trial run' has been carried out on the *barbadense* and *marie-galante* types, with the collaboration of the cotton breeders at Wad Medani.

The accessions mentioned in last year's report have been surveyed for blackarm. The commercial Upland types from Yugoslavia were uniformly susceptible while the French West African types were very resistant, averaging grade '2'. Three of these lines are being further selected to try and increase this high resistance which is evidently due to genes from *punctatum*. Of two accessions from Aden supplied by Mr. R. R. Anson, one was a *herbaceum* belonging to the race *acerifolium*. The other was close to *hirsutum* race *punctatum* but has some Upland characters and may have been of hybrid origin.

The collection of *G. herbaceum* race *africanum* is all very susceptible to blackarm. Results of the survey of other characters will be incorporated with the rest of the type collection.

Kadugli Station.

by K. C. Barlow

METEOROLOGY.

Apart from a period of drought in early July the season was favourable. Unfortunately most of the material on the experimental farm was sown in late June and germination was therefore variable and resowing considerable. After this difficult period, rains were good and conveniently spaced with intervening sunny periods. This enabled weeding to proceed unhampered and weeds did not tend to take root again. Waterlogging was rare and roads remained open for most of the rainy season. These conditions were in marked contrast to last season's rains.

The dry season was normal and cooler than last year. There was however a reversal of the usual cool dry north wind conditions in early February when 3 mm. of rain fell on the 3rd. of the month. This is very unusual.

Table 4. Rainfall mm.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Kadugli 1950	39.7	112.3	109.6	174.3	252.3	230.0	98.6	4.7	1,021.5
Kadugli 1951	—	204.7	80.0	169.6	103.9	146.3	120.9	—	825.4
Dilling ...	—	17.6	85.7	113.3	193.2	117.7	64.1	—	591.6
Lagowa ...	—	50.0	81.5	185.0	153.5	82.5	90.6	—	643.1
Talodi ...	—	112.0	125.5	193.0	113.0	119.0	126.5	—	789.0
Kalogi ...	—	69.9	117.5	192.7	121.4	89.2	134.5	—	725.2
Abu Gubeiha	—	10.3	77.4	239.3	109.0	91.0	163.0	—	690.0
Um Berem-beita ...	—	43.9	76.8	113.8	199.0	81.6	37.3	—	552.4
Abbassiya ...	—	73.0	34.0	131.5	200.5	138.0	46.5	—	623.5

Table 4A. Temperatures °C at Kadugli

	Mean Max	Range	Mean Min	Range
RESTING PERIOD.				
December 1950—May 1951 ...	37.4	40.6—33	19	23.3—15
GROWTH PERIOD.				
June 1951—November 1951 ...	33.3	36 —28	20.6	24 —18

COMMERCIAL COTTON.

Government seed issue was increased by 12,000 kantars (99 lb) to over 57,000 kantars. Favourable cultivation conditions, combined with this large seed issue, gave a record crop for the Nuba Mountains of 223,000 kantars. Blackarm was generally heavy but not as severe as last season. The favourable conditions of growth enabled the plants to grow away and dry spells gave temporary control. Bollworm damage was light except in localised cases. Crop hygiene again proved its worth, though there was some increase of pests since last season. Stainer bug (*Dysdercus spp.*) damage was negligible and this may have been due to the extension of the control campaign to all areas.

COTTON BREEDING.

Breeding work was extended this season and at the same time simplified in that it was concentrated on the general improvement of one variety. The progenies of 342 plants, selected from a crop of BAR. NT. 96/40 at Abdel Magid in the 1950/51 season, were sown on 3rd. July. Germination was good and after some initial hand-watering growth was excellent. Last season's experience of irregularity due to waterlogging resulted in vigorous efforts to level the breeding plot. Irregularities were consequently slight and growth very even within the progeny rows. Selection was focused on general improvement of habit, yield and seed-cotton characteristics, a special point being the exclusion of all rows not bearing the large bolls typical of the variety, with a high proportion carrying 5 loculi. Selected progenies were bulked and called BAR. NT. 96.1.

COTTON VARIETY TRIALS.

Kadugli Variety Trial.

Randomised block with seven varieties and six replications. Plot size 0.027 acres. Sown 4th. July at 90 cm x 90 cms spacing. Results are given in Table 5.

Table 5.

Variety	lb. lint per acre	G.O.T.
BAR. 7/8	744	34.4
BAR. SP 84.1	622	34.4
BAR. SP 84	604	30.6
BAR. SP 84.2	600	33.1
BAR. NT 96/40	590	33.1
BAR. 7/3	525	31.2
Pump Scheme Strain	376	28.8

Differences are not significant.

Due to the drought in early July great difficulty was encountered in establishing a stand. Millipedes and termites added to this difficulty. The seed of BAR. 7/3 was of poor germination because old seed was used by mistake. The Pump Scheme Strain was only sown to replace a failure of another variety when resowing seed ran out after 3 weeks of futile resowings. These two varieties cannot therefore be considered comparable.

BAR. SP84.1 was not as vigorous as BAR. SP84 but somewhat earlier. BAR. SP84.2 was weaker and would not compete with the rank weed growth of the Nuba Mountains. It should be noted, however, that its components were the quality types selected from the parent bulk. It might be found suitable for areas of extremely short growing period as a very high proportion of the crop was taken in the first picking and the third picking was very light. This opens up the possibility of the use of this type for mechanical picking.

Talodi Variety Trial.

Randomised block with five varieties and six replications. Plot size 0.03 acres. Sown 22nd. July at 90 cms x 90 cms after an earlier complete failure. Results are given in Table 6.

Table 6. Yields of Talodi Variety Trial.

Variety							lb. lint per acre	G.O.T.
BAR. 7/8	...	...	...	...	...	...	320	35.2
Pump Scheme Strain	...	...	...	...	...	...	284	30.4
BAR. SP 84	...	...	...	...	...	...	259	31.7
BAR. 7/3	...	...	...	...	...	...	258	32.5
BAR. NT. 96/40	...	...	...	...	...	...	243	32.6

Significant difference ($P = 0.05$) = 36.

Due to timely rain the poor germination capacity of the old seed used for sowing BAR. 7/5 was not so marked.

Lagowa Variety Trial.

Randomised block with five varieties and six replications. Plot size 0.03 acres. Sown on 16th. July at 90 cms x 90 cms. Results are given in Table 7.

Table 7. Yields of Lagowa Variety Trial.

Variety							lb. lint per acre	G.O.T.
BAR. 7/8	...	...	...	...	...	...	362	35.8
Pump Scheme Strain	...	...	...	...	...	...	337	
BAR. 7/3	...	...	...	...	...	...	338	
BAR. SP 84	...	...	...	...	...	...	300	33.0
BAR. NT 96/40	...	...	...	...	...	...	279	

As analysis of covariance was used there is a different significant difference for each pair of varieties. For simplicity, varieties which do not differ significantly at $P = 0.05$ have been bracketed.

The low rainfall of Lagowa brought out the effect of the use of old seed on the germination capacity of BAR. 7/3. In addition the germination of the remaining varieties was not as good as that of BAR. NT 96/40, the seed of which had been grown under irrigation and was consequently better filled. The negative regression of yield on number of dead holes was found to be significant and adjustments were made accordingly.

In all three variety trials blackarm was fairly heavy and there was some shedding of lower sympodia. The protection afforded by the genes B_2 and B_3 to the variety BAR. 7/8 is reflected in the yields. This was to a large extent due to the retention of the lower sympodia.

Spinning test data on current varieties have been summarised in Table 9 and yield data in Table 10.

Gannaya Observation Area.

25 acres of BAR. NT 96/40 were grown adjacent to 25 acres of commercial BAR. SP. 84 by a local cultivator. Severe drought followed sowing. BAR. NT 96/40, the seed of which had been grown under irrigation, grew well in the initial stages, but BAR. SP84 never caught up. The cultivator found that BAR. NT 96/40 was easier to pick, but this advantage was offset by a tendency to fall to the ground if picking was delayed.

WEEDING EXPERIMENT.

This experiment was sown with BAR. SP84, primarily as a demonstration to cultivators of the importance of early weeding. The layout was a randomised block of four treatments and six replications; plot size 0.06 acre. Sown 25th. June at 90 cms x 90 cms. spacing. Results are given in Table 8.

Table 8. Yields of Weeding Experiment.

Treatment						lb. seed cotton per acre
Clean Weeded	...	...	...	...	...	1,024
Weeded Early Only	...	...	...	...	...	916
Weeded Late Only	...	...	...	...	...	677
Left Dirty	...	...	...	...	...	643

Significant difference ($P = 0.05$) = 228.

Further analysis as a 2×2 experiment showed that the early weeding component was significant at $P = 0.001$ while that for late weeding and the interaction between the two were insignificant.

These principles are particularly applicable to the Baggara arabs who send their cattle and families north into the healthier areas during the rains. They remain and cultivate without much enthusiasm and frequently lose heart and follow their herds before the critical period is passed.

Table 9.
SUMMARY OF SPINNING TEST REPORTS ON CURRENT NUBA MOUNTAINS
STRAINS UP TO AND INCLUDING 1950-51.

Effective Length 32's				Standard Hair Weight				Corrected Lea-Count x Strength Product			
No. of Trials	Mean		No. of Trials	Mean		No. of Trials	Means of 40's cTs.		No. of Trials	Means of 50's cTs.	
	Variety	P.S.S. *		Variety	P.S.S.		Variety	P.S.S.		Variety	P.S.S.
BAR. SP 84	...	39	15	194	191	15	2200	2247	11	1968	2040
BAR. NT 96/40	...	39	7	198	190	7	2252	2268	4	1995	2066
		Variety		Variety	BAR. SP84		Variety	BAR. SP84		Variety	BAR. SP84
Pump Scheme Strain	...	37	15	191	194	15	2247	2200	11	2040	1968
BAR. NT 96/40	...	38	7	195	191	7	2254	2271	4	1983	2006
BAR. 7/3	...	38	1	181	181	1	2241	2332	1	2020	2142
BAR. 7/8	...	37	2	185	191	5	2138	2366	1	2016	2142
BAR. SP. 84.1	...	38	1	201	195	1	2265	2284	1	2011	2081

* Pump Scheme Strain.

Table 10.
SUMMARY OF PERFORMANCE OF CURRENT STRAINS IN KORDOFAN VARIETY
TRIALS UP TO AND INCLUDING SEASON 1951/1952.

Variety	SEED COTTON (lb/acre)			LINT (lb/acre)		Variety as % of P.S.S.
	No. of Trials	Variety	P.S.S.	No. of Trials	Variety	
Pump Scheme Strain...	59	966	966	50	280	100
BAR. SP 84 ...	16	986	1042	16	323	105
BAR. NT 96/40 ...	6	1267	1340	6	406	102

Variety	SEED COTTON (lb/acre)			LINT (lb/acre)		Variety as % of BAR.SP84
	No. of Trials	Variety	BAR. SP 84	No. of Trials	Variety	
BAR. SP 84 ...	20	1121	1121	20	364	100
BAR. SP 84.1 ...	2	1293	1475	2	441	95
BAR. SP 84.2 ...	1	1813	1974	1	600	99
BAR. 7/3 ...	4	1318	1372	4	430	99
BAR. 7/8 ...	5	1311	1276	5	452	112
BAR. NT 96/40 ...	7	1340	1384	7	433	97
Pump Scheme Strain ...	16	1042	986	16	307	95

PLANT BREEDING. CROPS OTHER THAN COTTON.

by P. D. Walton.

INTRODUCTION.

Work on dura this season has been confined to selections. Variety trials carried out by Evelyn and Moir had indicated the most suitable varieties for the major dura growing areas. Consequently the aim has been to obtain yield increases by selection within these varieties.

Early-generation seed of a sesame cross between an American variety and Langham's non-shattering mutant was obtained from America. It may well prove that this acquisition will reduce the work involved in the sesame breeding programme by several years.

The search for a lubia variety resistant to *Xanthomonas phaseoli* has been started this year. Inoculation techniques which were found to be successful during the previous season's work have been applied.

DURA.

A. SELECTIONS.

Selection work has been carried out in the following varieties :—

Wad Aker	
Martin's combine	Debekri
Feterita Wad Hussein	Mugud
Feterita Maatuk	Hemeisi White
Dwarf Milo	Feterita Suki
Abu Sabein	Feterita 1931

In all cases plants were selected which conformed to varietal type, as described by Evelyn, and which were high yielding. A final selection was made on grain quality.

B. EMASCULATION METHODS.

Trials of the hot water emasculation method were made with two objects.

- (1) To study the application of this method to making dura crosses.
- (2) To investigate the possibility of adopting this method to the production of duras exhibiting hybrid vigour.

In the first case heads were immersed for 10 minutes in water at temperatures ranging from 40° to 50°C and increasing by steps of 2°. In order to estimate the effect of the treatments part of each panicle was bagged and the remainder left to open-pollinate. Thus the extent of pollen kill could be obtained from the number of grains set in the bagged part and the effect of the treatment on the female parts could be obtained from the remainder of the head.

Temperatures between 46° and 44°C gave 100 per cent pollen kill with only slight damage to the rest of the head as the grain set in the open-pollinated part was 95 per cent at 44° and 90 per cent at 46°. Treatments were carried out when the anthers in the upper part of the head were beginning to turn yellow. Stage of maturity of the anthers in highly critical.

The possibility of adopting this method to the production of hybrid sorghums arose from the observation that it was possible to induce recurving in the goosenecked varieties, before pollen shedding, by stripping the leaf-sheath of the flag leaf from the stem for 2 or 3 ins. It would thus be possible to carry out emasculations without the cumbersome process of fitting the emasculator on to the head. In addition it was thought to be possible to reduce the time of immersion by using slightly higher temperatures for a shorter time and also by using wetters.

It was found possible to emasculate plants by immersion at 47°C for 5 min. About 15 per cent of the florets were damaged by the treatment. The introduction of a wetter at this temperature gave successful pollen kills in 4 min. with a similar amount of damage to the spikelets. Using these short immersion periods the temperature must be accurately maintained.

While preliminary investigations of this method show some promise, the time and labour required for production would detract from the returns obtained by the increased yield of the hybrids; also, in view of the recent developments in work with male sterile lines, it would seem to be inadvisable to continue to work on the production of hybrid sorghum by this method. Seed from male sterile lines should be available through Dr. Webster of the U. S. Department of Agriculture for work next season.

SESAME.

A. GEDAREF VARIETIES COLLECTION.

The collection, which contains 42 varieties, was grown this season on riverain land at Wad Medani. Good stands were obtained and data regarding plant characters, duration of flowering, maturation periods and yields was collected. There is little difference between many of the varieties. These duplicates will be grown for another season before being discarded.

B. LANGHAM'S NON-SHATTERING MUTANT.

A small sample of seed was obtained and was grown in the plant house. Germination was low and only enough plants developed to maintain seed supplies. The characters associated with non-shattering as described by Langham were observed.

The pods of this plant differ greatly from those of the local varieties, being shorter and broader and containing fewer seeds. It would seem however that the failure to shatter was due to the more fibrous and thicker locule walls rather than the fact that the locules contained less seed.

The maturation period of this variety is considerably longer than any one of the local varieties. This fact, together with its smaller pods and apparent lower yield potential, makes it unsuitable for local agriculture. It is however of considerable value as breeding material.

C. LANGHAM'S INDEHISCENT MUTANT x AMERICAN VARIETY.

This cross, mention of which has already been made was of the F₃ or F₄ generation and displayed a wide range of variation. Observations were made throughout the season and 100 plants were selected. The selections covered the whole range of variation but contained a majority of non-shattering types. The characters noted were branching of stem, cup-shaped leaves, presence of leaflets on the lower side of the leaves, maturation period, number of pods per stem, pods per axil, locules per pod and ease of threshing.

Selection No. 36, 38 and 58 had pods which closely resembled those of the local varieties and which did not shatter. Selections No. 37 and 61 classed as semi-non-shattering.

The maturation periods of the non-shattering plants ranged from 91 — 110 days with a mean of 104 days. This is considerably shorter than the mutant type but longer than local varieties which, grown under similar conditions, range from 81 to 96 days.

The possibility of introducing genetic material from local varieties into progenies from this cross must be considered at a latter stage.

D. SELECTIONS.

Seventy plants were selected from ECR/972, a variety introduced from America and first grown at the G.R.F. in the season 1948/49. These plants were vigorous off-types which appeared to be crosses between ECR/972 and a Gedaref variety in some cases, and between ECR/972 and ECR/1202 in others.

The progeny testing of these selections may give some indications of the extent of natural cross pollination. This, judging by the varying percentages reported, alters with changes in the environmental conditions. It may also be possible to select desirable types from the progeny of these chance out crosses.

LUBIA.

For use in any future work involving the breeding of a variety resistant to *Xanthomonas phaseoli* an investigation was made of the possibility of inoculating and grading two generations during one season.

Plants were subjected to short days of 9 hours. Flowering took place 41 days after the treatment commenced. Seed was harvested 40 days later. Under favourable conditions the disease will develop to a stage suitable for grading 10 days after the date of inoculation. Thus, provided that the planting date has been arranged so that at the onset of the rains the plants are sufficiently advanced to be sprayed with the inoculum, the following minimum period of high humidity is required :—

Development of disease after 1st inoculation	10 days
Short day treatment	41 days
Seed development	40 days
Initial growth of 2nd generation	21 days
Development of disease after 2nd inoculation	10 days
Total	122 days.

Thus at the G.R.F. in a year of average rainfall giving a suitable period of 138 days (mid-June to the end of October) it would be possible to grade and spray two generations.

Selection of a variety resistant to Xanthomonas phaseoli.

Thirty one varieties were introduced into the Sudan and planted in observation rows with the local variety as control. All varieties were inoculated with the disease. The degree of infection was judged on the size of the lesions produced. There was no resistance shown by any of the introduced varieties.

This should not be taken as an indication that resistance does not exist. There are 300 known lubia varieties and no doubt many more unnamed varieties are in use in native agriculture: so less than 10 per cent of the possibilities have been investigated. It is important that the size of the lubia collection be increased as rapidly as possible.

DR. WEBSTER'S VISIT.

A visit was made to Gedaref to meet Dr. O. J. Webster, sorghum breeder of the U. S. Department of Agriculture. It was possible to see together and discuss the local dura varieties of this area. Of even greater interest were the discussions on the introduced American varieties. Twenty six such varieties, including many combine types, had been planted in single rows. Dr. Webster stated that some of these combine varieties appeared to be growing as well in this country as they do in the United States. Nine varieties were selected as being suitable for further trial. Arrangements were made to obtain 2 lbs. of seed of each variety together with samples of other varieties which Dr. Webster considered to be suitable for the area.

In the case of the dwarf and double-dwarf varieties, it would seem that, due to their less extensive root system and the lower yield potential of the individual plants, a closer spacing is required than is used for the tall and intermediate types in order that comparable yields may be obtained.

The following local varieties were of interest either for direct use or as possible breeding material.

Feterita Maatuk. Liability to lodge makes the variety unsuitable for combine harvesting and complicates hand harvesting. It has been found over a series of years that it will yield moderately well in all seasons. Its use in the northern parts of the scheme is to be recommended until such time as it can be replaced by an introduced or locally bred combine variety. 100 plants have been selected for progeny testing.

Mugud. An attractive high yielding variety which appears to be well adapted to the southern part of the scheme. Unsuitable for combine harvesting. The white Mugud is considered more suitable for making kisra and fetches a higher price.

Wad Aker. Suitable for combine harvesting. This variety is reported to be susceptible to grasshopper damage. Wad Beshir, a variety like Wad Aker but less susceptible to grasshoppers, will be tested against Wad Aker during the coming season. 100 plants have been selected for progeny testing.

Feki Mustahi. Unsuitable for combine harvesting. The grain is of a high quality and is very popular for making kisra. The glumes are long and entirely enclose the grain. This character is reported to make the variety resistant to birds.

ENTOMOLOGICAL SECTION

by R. J. V. Joyce

I. Staff.

The work described in this report has been carried out by the following senior staff of the section. Some work carried out by entomologists of commercial firms has been included.

R. J. V. Joyce	Government Entomologist (general, jassid and whitefly ecology).
F. G. G. Peake	Forest Entomology.
D. G. Pollard	Insecticides.
A. T. Goodman	Cotton Pests at Tokar Delta.
W. S. Richards	Grasshoppers.
Bashir el Shafie	Control of Pests.
E. M. McDermid	Whitefly.
H. J. Morris	Desert Locust Survey.
Messrs., Tunstall, Dennis and Wright	} Seconded from Pest Control Ltd. Cotton Pests in the Gash Delta.
R. Amsden (Pest Control Ltd.)	Insecticides — Gezira.
M. Norman (Pest Control Ltd.)	Insecticides — Gezira.
N. Van Tiel (Shell Chemicals Ltd.)	Insecticides — Gezira.

II. General Survey of Insect Pests of Crops in the Sudan.

A. COTTON PESTS

BOLLWORMS (VARIOUS SPECIES) LEPIDOPTERA.

Gezira Scheme.

The pink bollworm, *Platyedra gossypiella*, Saund, (Gelechiidae) caused very little damage to cotton this season. Its incidence, in fact, was the lowest recorded since systematic sampling began in 1937. This was in spite of the poor clean up of the cotton areas during the dead season which followed the record crop of 1950/51 season. The number of bolls present per feddan this season was, however, only about half the number present during the previous season. The percentage of bolls infested was also about half (Table 1).

Table 1.

The sum of the average monthly total of bolls per feddan damaged by *P. gossypiella* during the past 14 years (in thousands)

Year	Total	Year	Total	Year	Total
1937/38	43.7	1942/43	46.3	1947/48	25.8
1938/39	40.5	1943/44	16.5	1948/49	17.0
1939/40	23.1	1944/45	12.2	1949/50	22.0
1940/41	38.3	1945/46	10.2	1950/51	15.4
1941/42	8.9	1946/47	9.8	1951/52	5.7

The areas from which these samples were taken included during this season Abu Gin Block in the new north western extension where cotton was grown for the first time. A high infestation for the season was recorded there, but this coincided with a greater number of bolls per feddan than in any other block. As usual the infestation in blocks near the river (Turabi, Tayiba, and G.R.F.) was higher than those farther away to the west (Fawar, Keteir, Abdel Galil and Wad El Bur). The early sown cotton in Hosh Block had a slightly higher infestation than that sown on the normal date.

The number of mature bolls damaged by the Egyptian bollworm, *Earias insulana*, Boisd. (Noctuidae), was almost exactly as during the previous season in the blocks sampled, but the percentage of bolls infested was higher.

The American bollworm, *Heliothis armigera*, Hamp. (Noctuidae), caused serious shedding in early sown cotton on the G.R.F. and at Kumor during October and November. It appeared to be more common than usual during this period in certain blocks in the Centre Group, but no detailed survey was carried out. In mature bolls *H. armigera* caused insignificant damage.

White Nile Schemes.

Samples of green bolls were taken from Hashaba and Fatisa at the end of January 1952, and examined for bollworm. Half of the area in each of these schemes was sprayed once and half twice with DDT in a large scale trial in jassid control and samples were taken from both treatments. The results are summarised in Table 2.

Table 2.

Incidence of bollworms on the White Nile
Schemes, Hashaba and Fatisa, on 30th. Jan.
1952. (in thousands per feddan).

Scheme	Details	Sprayed once	Sprayed twice
Fatisa ...	Total bolls per feddan	152.1	158.7
	No. damaged by P.B.W.	7.9	2.5
	No. damaged by E.B.W.	0.9	0.3
Hashaba	Total bolls per feddan	73.0	58.6
	No. damaged by P.B.W.	3.8	1.1
	No. damaged by E.B.W.	3.0	0.8
No. P.B.W./feddan. Mean of both areas		4.0	1.5
No. E.B.W./feddan. Mean of both areas		1.6	0.5

The results suggested that some control of both species may have been achieved by the second spray. This is consistent with the result obtained from a similar experiment carried out in the Gezira Scheme during the season 1949/50.

Northern Province.

In the Dongola and Merowe areas cotton again became a popular crop for the first time since before the war. A survey of cotton pests was made in October and November 1951 over 30 schemes in the area. The incidence of pink bollworm was extremely low, being absent from samples taken in one third of the schemes. Maximum incidence recorded was when 2 per cent of the sample of green bolls were found damaged. This is in marked contrast to the Shendi area farther south. Earias however caused important losses of buds and young bolls and in some schemes was responsible for appreciable damage to large bolls. Neither *Heliothis* nor *Diparopsis* were recorded.

In the Shendi area pink bollworm infestations were lighter than during the previous season, increasing from a mean of 3 per cent of the August bolls damaged to 48 per cent in October, compared with 15 per cent in August and nearly 70 per cent in October of the previous season. Egyptian bollworm caused only slight damage and, as in Dongola, *Heliothis* and *Diparopsis* were of no importance.

A notable degree of parasitism of larvae of pink bollworm by *Microbracon kirkpatricki*, Wlk. (Hymenoptera: Braconidae) was recorded in the Shendi district in November.

Khartoum Province.

Pink bollworm continued to be the major pest of cotton in Khartoum Province throughout the picking season. At the end of the cropping season as many as 75 per cent of the bolls were often recorded as infested. Egyptian bollworm was never responsible for any damage of importance.

Kassala Province.

Gash Delta.

Pink bollworm was not recorded on the crop until March when it was found in small numbers on only three of the seven stations in the Gash sampled. It was not responsible for any measurable reduction in yield.

The Egyptian bollworm was lighter than usual on buds and young bolls in November and December, but its damage to mature bolls was much the same as in previous seasons. This bollworm is always present in the Gash but never seems to have any serious effect upon yield. American Wilds cotton was severely attacked by *Earias* in October, when damage to growing points by this bollworm was conspicuous.

The Sudan bollworm, *Diparopsis perditor*, Clevr. (Noctuidae) was as usual the most important pest of cotton in the Gash. Its incidence on buds and young bolls in November and December was, however, very much less than in previous seasons. In January conspicuous damage to mature bolls occurred at all stations sampled, but especially in the most northerly station, Hadaliya. Damage in the perennially irrigated areas in Wad Sharefei was unusually severe. Although during the present season *Diparopsis* was less numerous than for many years, it was still responsible for important losses in yield. American Wilds cotton especially suffered. In this variety also damage by *Diparopsis* to growing points was recorded.

In Table 3 is summarised the average number of damaged bolls per feddan during the years when observations have been made.

Table 3.

The sum of the average monthly total of bolls damaged by bollworms in Gash Delta. (in thousands per feddan).

Year	Damaged by		
	P. gossypiella	E. insulana	D. perditor
1943/44	23.5	9.2	16.0
1944/45	Records incomplete		
1945/46	"	"	
1946/47	"	"	
1947/48	0.0	1.6	27.5
1948/49	1.4	4.7	17.3
1949/50	16.7	1.4	4.9
1950/51	1.7	4.9	25.9
1951/52	0.1	3.2	7.2

The American bollworm was recorded damaging buds and young fruits of American Wilds cotton growing experimentally in the Gash. It was also found occasionally on young fruits of Egyptian cotton in November and rarely on mature bolls in January.

Tokar Delta.

Pink bollworm was first recorded in Tokar delta in February, but in negligible numbers. The maximum damage occurred in March when 15 per cent of the bolls were found infested.

Earias attacked young cotton plants 6 weeks after planting and destroyed growing points, as many as 12 per cent of the plant holes in some areas showing this damage. Neither loss of buds and young fruits by *Earias* nor damage to mature bolls is thought to have noticeably affected yield.

Heliothis was again the most conspicuous bollworm on cotton especially at the time of harvesting of the dura and dukhn windbreaks, on which this pest breeds.

Damage to buds and young bolls was extremely high during December and January, but detailed observations on crop growth (p. 136) have cast doubt on whether this loss of fruiting points is responsible for any final lowering of yield.

Nuba Mountains (Rain grown).

In the Kadugli District the incidence of pink bollworm was alarmingly high in October, but numbers declined in the sampling areas during November and December. This is unusual as it is during these months that rapid increase is expected. In the Eastern Jebels some serious infestations occurred in November and December. There is no doubt that *Platyedra* was responsible for important crop loss during the season.

The Egyptian bollworm was no more numerous than usual in both Kadugli District and in parts of the Eastern Jebels where December the percentage of bolls damaged was sometimes over 15 per cent.

The Sudan bollworm caused very serious shedding of young fruiting points in October and November and was responsible during October for serious damage to mature bolls. There is no doubt that this pest is of major importance in the Nuba Mountains.

In Table 4 the records of the last three seasons are compared by tabulating the total of the monthly average of bolls per feddan damaged in 9 localities sampled near Kadugli.

Table 4.

Total of the monthly average of mature bolls per feddan damaged by bollworms in three seasons (in thousands per feddan).

Year	Bolls per feddan damaged by			
	P.B.W.	E.B.W.	S.B.W.	A.B.W.
1949/50	30.8	4.7	3.3	0.0
1950/51	9.2	7.7	6.3	0.4
1951/52	31.4	7.4	26.7	0.0

Shedding of buds and young bolls was serious in most areas but on Kamina Farm at Kadugli, from which area alone data are available, it was lighter than usual. Shedding in the Kadugli area is compared over the past three years in Table 5.

Table 5.

The cause of shedding buds and young bolls in August and September in various sampling areas near Kadugli in three seasons.

Year		Total sheds collected		Percentage of sheds damaged by			
				P.B.W.	E.B.W.	S.B.W.	A.B.W.
1949/50 ...	Aug.	400	—	—	17	48	—
	Sept.	2800	—	—	9	13	7
1950/51 ...	Aug.	455	—	—	12	36	—
	Sept.	400	—	—	4	7	10
1951/52 ...	Aug.	935	1	5	5	11	1
	Sept.	553	4	5	5	5	4

(Note: in 1951/52 observations on shedding were confined to Kamina Farm, Kadugli).

Abu Hahl Scheme.

Cotton on the Abu Hahl Scheme was sown between October and early November. The late sowing resulted in poor early growth. Bollworm attack was light throughout the season, although all species were recorded.

Equatoria Province.

Pink bollworm again proved to be the major pest of cotton in Equatoria although reports this season are scanty. Damage was widespread and the pest was certainly responsible for serious crop losses.

Kassala Province (Rain grown).

Pink, Egyptian, American and Sudan bollworm were again recorded on rain grown cotton in the Gedaref District. Damage to mature bolls was not heavy, and the most important bollworm was *Earias*. Serious shedding of early formed fruits was recorded in several localities, most sheds being associated with bollworm attack.

COTTON THRIPS. *HERCOTHRIPS* SPP. (THYSANOPTERA).

Both *H. fumipennis*, Bagn & Cam. and *H. sudanensis*, Bagn, & Cam. were recorded on cotton at the G.R.F. in small numbers in September. In the South Group of the Gezira light breeding was observed during the third and fourth week of September when at the same time very large numbers could be observed on weeds of the fallow. In mid-October very large numbers of *H. fumipennis* invaded the cotton in South and centre Groups, causing serious damage and leaf shedding particularly in Wad Naaman and Fahl Blocks. Damage by the same species was by no means uncommon in Messellemlia and North Group, but here it was seldom serious. An interesting feature of the thrips infestation in the south was the serious damage in late October suffered by crops that had been sprayed with DDT by ground machine earlier in the month. Two factors undoubtedly contributed to this disappointing result. Firstly the heavy rains which occurred in the southern Gezira in early October soon after spraying probably washed the DDT from the leaves. Secondly the plants were young when sprayed and growing rapidly and the thrips invading from weeds later in the month were able to infest new leaves which had not been sprayed.

On the White Nile *H. fumipennis* caused serious leaf-shedding in all cotton schemes south of Dueim. In Aba Island cotton suffered serious damage before spraying took place in mid-October. Some serious infestations were recorded in schemes north of Dueim but the infestations were less widespread and were controlled early by jassid spraying.

In the Gash, there was little damage from thrips although some small areas suffered from *H. fumipennis* in October and *H. sudanensis* in December and January. No thrips damage was recorded in Tokar.

In the rain sown cotton areas of Gedaref district *H. fumipennis* caused devastating damage to unsprayed cotton, much of which was destroyed. Most of the cotton, however, was sprayed against thrips and infestation controlled.

Thrips were rarely recorded in the Nuba Mountains but Abu Habi cotton suffered very seriously. In this Scheme, where the cotton was very late sown, *H. fumipennis* invaded the cotton from the weeds

whilst it was still in the cotyledon stage, killing the young plants. Resowing was not possible and serious loss of crop resulted. It did not prove possible to protect the crop from this type of attack by spraying as the attack was so sudden.

WHITEFLY. *BEMISIA TABACI*, GENN. (HEMIPTERA: ALEYRODIDAE).

The season was exceptionally favourable to whitefly and infestations on cotton were higher than have been recorded for many years. Adult whitefly were conspicuous on young cotton in mid-September especially in the southern Gezira where breeding took place on a large scale in October and the cotton, especially at Wad Naaman and Fahl, began to look very poor from the combined attack of whitefly and thrips, and asal began to be conspicuous. By November whitefly and asal were widespread throughout the Gezira and the attack was associated with severe leaf-shedding and in the south with the death of plants.

Although whitefly numbers were greater on X1730 than on Sakel cotton, the latter variety suffered much more severely. The worst damage was to fields of Sakel growing in the southern Gezira. In Wad el Bur, which was the most southerly Sakel area in the Scheme, the cotton in January in many fields had shed almost all of its leaves, and many of its fruiting branches. Only cotton growing in a few of the northerly areas, such as the new northwest extension, escaped from the serious leaf-shedding which was associated with whitefly attack.

On the White Nile Schemes also whitefly was exceptionally severe, especially in Aba Island and Um Gerr, where leaf-shedding was serious and permanent wilting, associated with high whitefly numbers, widespread.

In the Gash whitefly were more numerous than usual in September and October but were not responsible for any appreciable damage. In Tokar asal associated with whitefly was reported as serious in cotton adjacent to dura windbreaks.

Whitefly were not noticeable on rain grown cotton.

JASSIDS. *EMPOASCA LIBYCA*, DE BERG (HEMIPTERA: JASSIDAE).

Surveys of the incidence of jassids in the Gezira have been carried out at the same dates in late September during the last three years. The results are compared in Table 6.

Table 6.

Incidence of *E. libyca* in the Gezira from
18-30 September. Number of nymphs per
100 leaves. (Means of counts).

Group	1949	1950	1951
North	3	4	1
K.C.C.	22	6	N.A.
Messellemia	16	13	1
Centre	N.A.	18	7
South	14	16	4

The result of a similar survey of the White Nile and private schemes are summarised in Table 7.

Table 7.

Incidence of *E. libyca* on certain schemes
1-10 October, 1950.
Numbers of nymphs per 100 leaves.

Schemes	1949	1950	1951
Fatisa	112	115	120
Hashaba	57	241	126
Abdel Magid	56	53	38
Dueim	N.A.	127	220
Wad Nimr	N.A.	150	96
Um Gerr	N.A.	34	186
Busata (Fung)	N.A.	92	N.A.
Aba Island	N.A.	35	N.A.
Shabasha	—	—	41
Wakra	—	—	121

In the Gezira these early infestations were generally lower than in the previous season. Again infestations in the south were greater than in the north. On the White Nile Schemes initial infestations were generally lower, but in some schemes conspicuously higher, than in the previous year. As usual initial infestations were much higher on the White Nile than in the Gezira.

About 95 per cent of the total area under cotton in the Gezira and nearly 100 per cent of the cotton on the White Nile was sprayed with DDT between late September and early November. Jassid damage on the small areas of unsprayed cotton was extremely variable, but generally more severe than during the previous season. The available counts of peak infestations are of doubtful value.

A conspicuous feature of the season was the not infrequent occurrence of jassid damage to cotton after spraying. The following combination of factors are thought to have been responsible (i) October rain, which occurred after spraying (ii) continued invasion of cotton from fallow weeds which owing to the late rains continued to grow vigorously during October (iii) conditions during October being favourable for jassid development.

In Northern Province damage by jassids was sometimes conspicuous and undoubtedly depressed yields. In the Gash *E. libyca* was considerably more abundant than usual and spraying experiments indicated that this pest can seriously reduce potential yields. In Tokar delta *E. libyca* was abundant but its status as a pest is uncertain.

None of the rain-grown cotton suffered from serious attack by jassids.

COTTON APHIDS. *APHIS GOSSYPHII*, GLOVER (HEMIPTERA: APHIDAE).

Cotton aphid was rather more numerous than usual during January and February in the Gezira area but was not a serious pest. On some of the private pump schemes on the White Nile, however, aphids were suspected of having been responsible for some reduction of final yields. In the Gash and Tokar they were rarely recorded and certainly did no damage. On rain grown cotton aphids were of no importance.

COTTON STAINERS. *DYSDERCUS* SPP. (HEMIPTERA: PYRRHOCORIDAE).

Both *D. fasciatus*, Sign. and *D. supersticiosus*, F. were recorded in small numbers on tebeldi trees (*Adansonia digitata*) in the Nuba Mountains during the dry season of 1951. Numbers of *D. fasciatus* increased on tebeldi during the rains but *supersticiosus* was commoner on cotton in Kadugli district. Damage to green bolls in the Kadugli area was extremely light but slightly worse damage occurred in the Eastern Jebels.

A few *D. supersticiosus* were recorded in Tokar delta.

Various species of stainers of which *D. supersticiosus* was the commonest caused serious damage to cotton in Equatoria.

COTTON CAPSIDS. (HEMIPTERA: CAPSIDAE).

Helopeltis bergrothi, Reut. No reports of damage were received during the season.

Creontiades pallidus, Ramb. In Northern Province *C. pallidus* invaded cotton at Zeidab at flowering and its presence was associated with considerable shedding. In Tokar delta detailed studies were made

on this pest which was abundant in cotton after harvesting of the dura and dukhn. Although its occurrence on cotton was associated with serious shedding of buds it seems doubtful that it was responsible for any important reduction in yield (see p. 136).

COTTON FLEA-BEETLE. *PODAGRICA PUNCTICOLLIS*, WEISE
(COLEOPTERA : HALTICIDAE).

In the Gezira flea-beetle attack was probably the worst recorded. July-sown cotton was very badly damaged in August, the attack coinciding with the first heavy rains of the season. Flea-beetle increased during August and September when cotton planted at the normal sowing date was severely damaged. The most serious damage occurred in Centre Group, but the northern part of South Group and the southern part of Messellemia Group also contained areas of severe damage. In Centre Group damage was not confined to the edges of cotton fields but was often serious throughout early September, and where flea-beetle attack was followed by thrips and whitefly, as in South Group, the plants never really recovered. In an attempt to encourage growth of attacked cotton many Inspectors watered liberally. Unfortunately this heavy watering was frequently followed by heavy rain, so that the ground remained wet for long periods encouraging weed growth and blackarm. There is no doubt that flea-beetle, both directly and indirectly was a major factor in reducing cotton yields.

On the White Nile Schemes, while flea-beetle were more numerous than usual, they did not cause such serious damage as in the Gezira except in some of the more southerly private schemes, such as Abu Island, which were badly attacked.

In the Gash delta young cotton suffered some damage but breeding continued in the crop throughout the season causing some leaf damage. Flea-beetle probably caused significant reduction in yield. In Tokar delta, on the other hand, they were few in number.

Throughout the rain cotton areas of Gedaref, Nuba Mountains and in the Abu Hahl Scheme serious damage by flea-beetle to young cotton occurred. In the Abu Hahl it was particularly serious, since plants were destroyed and resowing was not possible.

COTTON STEM BORER. *SPHENOPTERA GOSSYPHII*, COTES. (COLEOPTERA : BUPRESTIDAE).

This pest occurred in small and unimportant numbers in the Gezira and White Nile Schemes and was responsible for only a very minor part of the serious wilting which occurred in October and November. In the Gash delta counts taken during the season revealed numbers which were much the same as usual.

TERMITES. (ISOPTERA).

Although wilting was widespread in the Gezira and White Nile only a part could be attributed to primary attack by termites. On the other hand in Tokar delta termites continued to be a most important pest. By attacking healthy and fully grown plants they are estimated to have been responsible for a loss of 25 per cent of the crop (see p. 137).

COTTON LEAF ROLLER. *SYLEPTA DEROGATA* (LEPIDOPTERA : PYRALIDAE).

This pest attacked isolated areas in the Nuba Mountains causing severe leaf-stripping, but nowhere was it sufficiently numerous or widespread to cause any important reduction in yield.

OTHER PESTS.

Millipedes (species unknown) attacked young cotton in the Nuba Mountains and Gedaref. Grasshoppers (*Pyrgomorpha* spp.) were far less frequent than usual in cotton in the Gezira and *Catantops* spp. caused a little damage in the Gedaref district. Neither in the Gash nor Tokar were any Orthoptera recorded doing damage. *Adesmia milaris*, Rche. (Coleoptera : Tenebrionidae) was again reported damaging cotton stems in the Gash. Rats caused some concern in the Gash during September and October but no damage was reported.

B. PESTS OF DURA.

Desert Locust (*Schistocerca gregaria*, Forsk). Swarms invaded the Sudan during June and July but in the absence of early rains no breeding occurred and no crop loss was suffered.

Tropical Migratory Locust (*Locusta migratoria migratorioides*, P & F). No swarms occurred during the present season, and no damage from *solitaria* or *congregans* was reported.

Grasshoppers. *Aiolopus savignyi*. Kr. did some minor damage to seedling dura in the Gedaref district in July, and some more serious damage on the Gezira Research Farm, in the northern Gezira to irrigated and in the central Gezira to rain dura; considerable numbers persisted until August. No damage to milky or ripening dura occurred in the Gezira, but in the Gedaref area some serious crop loss occurred at Ghadambaliya and to a lesser extent at Um Sugura; it was noticed that *Aiolopus* showed a preference for crops showing water strain.

Dura Stemborer *Sesamia cretica*, Led. (Lepidoptera : Noctuidae). The incidence of this pest appears to vary little in the Gezira from year to year. Early sown dura on the Gezira Research Farm suffered but later sown crops were never seriously attacked. In Northern Province stemborer remained the worst pest of dura but of recent years damage in the Shendi area appears to have declined. In the Gash attack appeared to be considerably lighter than usual. In the Gedaref area seedlings were attacked commonly, and mature dura seldom. In the Nuba Mountains stemborer was abundant on ripening dura, which nevertheless still yielded well.

Dura Andat. *Agonoscelis versicolor*, F. (Hemiptera : Pentatomidae). The annual survey of the aestivating quarters of the bug in the affected areas of the Blue Nile and Kassala Provinces revealed that concentrations were far fewer than in the previous season particularly in the southern blocks of the Gezira. Damage to crops was unimportant throughout the country.

Dura Midge. Contarinia sorghicola, Coq. (Diptera : Cecidomyidae). At the Gezira Research Farm damage was conspicuous on a number of dura heads in October but later on the infestation decreased considerably. Light damage was also noted in the South Group of the Gezira and in certain localities of the Nuba Mountains of Kordofan Province.

Dura Aphis. Aphis sorghi, Theo. No loss of crop from dura aphis was reported although the pest was widespread and especially conspicuous on well watered irrigated crops.

OTHER PESTS.

Birds. In spite of the vast incursions of swarms of *Quelea quelea aethiopica*, Sund (the Sudan Dioch or weaver bird) into the Blue Nile region, no serious damage to crops was caused. A report from Darfur indicated that large flocks of birds, most probably *Quelea*, bred and caused serious damage to crops. This species also caused damage to seedlings of *Acacia arabica* near Singa. In Northern Province the Spanish sparrow (*Passer hispaniolensis*) and the House Sparrow (*Passer domesticus arboreus*, Bs.) inflicted appreciable damage to crops in winter (January-March) in certain parts of Dongola area.

Millipedes appeared in May and were common in June and July in Nuba Mountains. They were troublesome to seedlings of crops of all kinds.

C. PESTS OF VARIOUS CROPS.

PULSES.

In Northern Province pests of pulses continued to do a limited amount of damage to crops. Lubia suffered from heavy asal as a result of a bad attack of whitefly (*Bemisia tabaci*) at Gendittu Scheme in July. Berseem and Egyptian beans (*Vicia faba*) at Aliab Pump Scheme suffered a heavy loss as a result of attack by cutworms (*Laphygma exigua*, Hubn). The beans also suffered from attack by *Aphis laburni*, Kalt. Incidence of cutworm (*Agrotis ypsilon*, Hb.) on chick peas (*Cicer arietinum*) was low this season. This pest which is usually responsible for heavy loss of crop in Tabga basin was rare this season. Late sown haricot beans were severely attacked by *Hercothrips fumipennis* and at Gendittu 30 feddans of crop were completely destroyed.

In the Gezira incidence of whitefly was high on legumes. On lubia the attack was exceptionally severe in September, October and November and in particular at Wad Naaman Block where whole fields were completely destroyed. Lubia flea-beetle, *Luperodes quaternus*, Faim. (Coleoptera : Halticidae) was common on September-sown lubia and in certain instances caused considerable loss at the Gezira Research Farm. Larvae of *Adoretus convexicollis*, Fairm. (Coleoptera : Rutelidae) also appeared this season on lubia at the Gezira Research

Farm. Lubia jassid (*Erythroneura lubiae*, China) and American bollworm were also present in small numbers. Large numbers of various species of grasshoppers and in particular *Aiolopus savignyi* did a certain amount of damage to lubia seedlings in certain localities. Lubia seedlings were also seriously injured by blister beetles (*Epicauta aethiops*, Latr.). On berseem American Bollworm, *Colias marnoana*, Rozen., *Therioaphis ononidae*, Kult., *Hercothrips sudanensis* and *H. fumipennis* were noted throughout the season. On the Gezira Research Farm black velvet beans suffered severely from blister beetle. The hairy caterpillar, *Amsacta meloneyi*, Druce (Arctiidae) caused slight damage to Sesbania trees.

OIL SEEDS.

In Northern Province, sesame was attacked by the webworm, *Antigastra catalaunalis*, Dup. (Lepidoptera : Pyralidae). In Kordofan Province this species also caused some damage in parts of the Nuba Mountains where also the seed bug, *Lophanthus litoralis*, Dist. (Hemiptera : Lygaeidae), inflicted heavy loss on harvested pods especially at Lagowa and Abu Gebeiba.

Safflower at the Gezira Research Farm and Wad El Nau was severely damaged at the flowering stage by caterpillars of *Heliothis peltigera*, Schiff. associated with small numbers of *Eublemma parva*, Hb. (Lepidoptera : Noctuidae). Young castor plants at the Gezira Research Farm and Wad El Nau suffered to a certain extent from grasshopper attack the most destructive being *Pyrgomorpha cognata*, Kr. *Eublemma brachygonia*, Hamps. was common on castor heads, larvae sometimes causing severe damage to the maturing seed. Sunflower at Wad El Nau was seriously damaged in its earlier stages by *Epicauta aethiops*. Other pests which occurred in numbers on sunflower were *Bemisia tabaci*, *Xanthodes graellsii*, Feist. (Lepidoptera : Noctuidae), *Heliothis armigera*, *Campylomma nicolasi*, Reut & Put. (Hemiptera : Capsidae) and *Hercothrips fumipennis*. On groundnuts termites were common and caused considerable loss to crops at the Gezira Research Farm and Wad El Nau.

FIBRES.

Deccan hemp suffered from attack by cotton flea-beetle, whitefly, *Empoasca libyca* and *Xanthodes graellsii*.

FRUIT TREES.

In Khartoum and Northern Provinces control operations against hibiscus mealy bug, *Phenacoccus hirsutus*, Green. (Hemiptera : Coccidae) continued. An outbreak of guava mealy bug, *Ferrisia virgata*, Ckll., occurred on various kinds of fruit trees in Kassala gardens. In Northern Province the fruit fly *Pardalaspis quinarii*, Bez. (Diptera : Trypetidae) was kept under careful watch. For two successive years, 1949 and 1950, the activity of this pest was confined to Shendi and Gendittu Schemes only, but in 1951 it extended to Metemma citrus gardens and Nuri Government Pump Schemes. This year (1952) it occurred in Shendi, Metemma and Nuri. Red Spider *Paratetranychus*

simplex, Herst (Acarina: Tetranychidae) was recorded as serious on citrus in Gendittu in July. At Fadlab it was serious on citrus in October. Scale insect, *Lepidosaphes beekii*. Bez. (Hemiptera: Coccidae) was found on mango trees at Gandittu.

GENERAL PESTS.

Rats were troublesome in Northern, Kassala, Khartoum and Blue Nile Provinces. They caused appreciable losses to crops in the field and to stored products.

The month of June 1951 was marked by a heavy infestation of the grasshopper *Cyrtacanthacris tartarica*, L. which concentrated on field crops, citrus trees and green vegetation in Gezira gardens. This happens not infrequently when the cotton crop is pulled out in May.

III. The Ecology of the Cotton Jassid

Empoasca libyca, de Berg.

GENERAL.

Dry season surveys in the southern Gezira and northern Fung confirmed dry season breeding on *Balanites aegyptiaca*, Del (Simarubaceae — the heglig tree). Records of catches in sticky and light traps at G.R.F. and Wad El Haddad indicated :—

- (i) Considerable flight of jassids from June until mid-August in both areas, but less than in 1949/50 and 1950/51.
- (ii) Large numbers in flight at G.R.F. in October, a phenomenon not recorded in previous seasons when low catches were obtained at this time of the year.
- (iii) During the June to August period catches were greatest on sticky traps facing south.

These results are consistent with the theory that considerable immigration from areas south of the Gezira may take place. They also indicate that movement of jassids during October was considerably greater than usual.

Surveys of weed host plants during July and August indicated that in 1951 fallow weeds played an insignificant part in the build up of population in the Gezira prior to sowing of the crop, as was to be expected from the late onset of the rains. Weeds in dura may have been important. During September and October large populations were recorded on *Solanum dubium*, Fresen (Solanaceae), *Rhyncosia memnonia*, Berth (Papilionaceae) and cotton seedlings. These may have played a very important part in the subsequent development of infestation on cotton.

Infestation on cotton was lighter in the Gezira in September than in 1950/51 season. On the White Nile infestations were much the same. Indeed here they appear to remain uniformly high from season to season. In both areas the population bulked up rapidly and in the

Gezira as a whole jassid numbers, assessed as counts per 100 leaves, were higher than in the previous season. Damage on unsprayed cotton was correspondingly greater. As the total sprayed area increases it becomes more difficult to assess the peak populations from year to year. The data collected indicate however that the peak populations, as measured by numbers of jassids per plant-hole were greater in 1951/52 than in 1950/51.

More data were collected on the rate of breeding of jassids on manured and unmanured land. Preliminary examination of the results indicates that breeding is more rapid on manured plants and this seems to be associated with more rapid plant growth. The results of the counts are consistent with the observation that jassids choose young leaves for egg-laying.

Double spraying with DDT on White Nile Schemes.

Infestation of cotton by the jassid *E. libyca* is usually more severe on the White Nile Schemes than in the Gezira. In previous years when cotton had been sprayed in September and October considerable reinfestation had occurred accompanied by severe leaf damage which was thought to have lowered yields. An experiment was therefore planned during the present season designed to investigate the effect of this infestation on yields.

In the two schemes Hashaba and Fatisa where the first spraying with DDT had been completed by mid-October arrangements were made to respray half the area in November with DDT wettable powder applied at $\frac{1}{2}$ lb technical DDT per feddan, the area to be resprayed being chosen by the Inspector in charge of the scheme. The experiment can be considered as an experiment in which two treatments (sprayed once and sprayed twice) were randomised and replicated over 200 times.

Regular jassid counts were not possible but the effect of the second spraying on jassid infestation is indicated by the counts summarised in Table 27. The cotton sprayed twice was easily distinguished in the field by the greater luxuriance of vegetative growth and absence of jassid damage. There is no doubt that the second spray achieved a considerable degree of control of the reinfestation, the effect still being apparent 6 weeks after spraying.

Table 27.

Effect of double spraying on jassid infestation in two White Nile Schemes 1951/52.

Counts taken in Jan. 1952 viz 60 days after the 2nd. spraying.

(Nymphs per 100 leaves : means of 10 samplings)

[illegible]

The effect of double spraying on bollworms is summarised in Table 2. (p. 108). There are indications that some measure of control of both *P. gossypiella* and *E. insulana* was attained.

Yield results are summarised in Table 28. The second spraying gave no increase in yield and there were no significant differences between treatments, a result consistent with large and small scale experiments in the Gezira where failure to obtain yield response to a more complete control of jassids has been attributed to nitrogen deficiency.

Table 28.
Effect of double spraying on yields in
two White Nile Schemes 1951/52
(k.p.f.)

Treatment							Hashaba	Fatisa
Sprayed once	...	...	...	...	...	...	2.76	3.09
Sprayed twice	...	...	...	...	...	...	2.69	2.93

IV. The Ecology and Control of the Cotton Whitefly. *Bemisia tabaci*, Genn.

General Observations.

Preliminary observations confirmed earlier records of continuous breeding of whitefly during the dry season on a wide range of host plants in irrigated gardens, the infestations increasing rapidly on the new growth which occurred at the onset of the rains. The growth of fallow weeds during the present season coincided with the germination of cotton, and weeds and crop were colonised at the same time. Breeding during September was considerably greater on cotton than on weeds and it appears doubtful whether breeding on weeds played any important part in the subsequent infestation of cotton. Early sown lubia, however, was heavily infested from the time that it germinated in July and there seems no doubt that this breeding was of considerable local importance.

Study of the records has revealed over 150 host plants in 29 different families. Of the host plants recorded in the present season, the following appeared to be of greatest importance:— *Hibiscus cannabinus*, L., *H. esculentus*, L. (Malvaceae); *Solanum dubium*, *S. melongena*, L. (Solanaceae); *Dolichos lablab*; *Sonchus oleraceus*, L. (Compositae); *Ipomoea cordofana*, Choisy, *I. cardiosepala*, H. (Convolvulaceae); *Ocimum basilicum*, L. (Labiatae); *Phyllanthus* spp. (Euphorbiaceae); *Lantana* sp. (Verbenaceae); *Corchorus* sp. (Tiliaceae); *Gynandropsis gynandra*, L. (Brig) (Capparidaceae); *Heliotropium* spp. (Boraginaceae); and *Aristolochia bracteolata*, Lam. (Aristolochiaceae).

Observations by means of plant diagrams have revealed that oviposition is largely confined to the young leaves on the upper parts of the plant, where the young stages occur in greatest numbers. During the present season eggs were first observed in early September. Infestation developed very rapidly during October and reached its peak in early November after which the population declined rapidly until in January numbers of all stages were low. No increase in numbers took place before the crop was pulled in April-May.

Severe infestations were associated with severe shedding of leaves. Very severe infestations were associated with the drying up of leaf petioles and fruiting branches which remained on the plant as dead organs until they got broken off. In heavily infested fields in October and November wilting of single plants in a plant hole was a common and characteristic feature. This wilting was most frequent in areas unfavourable for cotton growth such as waterlogged or very weedy fields.

Control : Large scale experiment.

A large scale experiment in the control of whitefly was carried out at Wad Naaman and Fahl, two areas of X1730 cotton in the southern Gezira where exceptionally severe infestations became noticeable in September. In each block certain cotton numbers (standard areas each of 90 feddans) were selected. In each cotton number, which contained 9 standard tenancies each of 10 feddans, alternate tenancies were sprayed with parathion, the remainder being left as unsprayed controls. Table 12 shows the areas in the experiment.

Table 12.

The numbers of 10 feddans tenancies used in
whitefly experiment : S.G.B. 1951/52.

	Fahl			Wad Naaman		
	Utilised	Sprayed	Unsprayed	Utilised	Sprayed	Unsprayed
Total in Expt.	96	51	45	77	45	32
Total sampled	40	21	19	38	20	18
% sampled	42%	40%	42%	50%	44%	56%

Through a combination of unfortunate circumstances it was not possible to begin spraying until late November and spraying continued into December. The cotton in these areas had already suffered a severe set-back to growth by the combined attack of flea beetle, thrips and whitefly and when spraying began was extremely stunted in growth.

Spraying was carried out using $\frac{1}{4}$ lb. parathion in 100 gals water per feddan applied by tractor-drawn spray equipment with a boom fitted with droplegs.

Assessment of infestation was carried out by examination of 6 leaves of each of 100 plant holes in each tenancy and recording whether each was infested or uninfested by live scales of whitefly. The pre-spraying count gave 100 per cent infestation in all fields. This was reduced to a mean of 27 per cent infestation over 44 sampling areas in Wad Naaman 2 weeks after spraying. However unsprayed areas showed a reduction to about 50 per cent and infestations on both sprayed and unsprayed tenancies declined in a similar degree throughout the 6 weeks period of observation. These results were confirmed by detailed counts of eggs and live scales when samples from sprayed areas showed a mean of 10.6 eggs and nymphs per sq. cm. of leaf area 4 weeks after spraying while those from unsprayed areas showed a mean of 28.3 eggs and nymphs per sq. cm. of leaf area after a similar period. Four weeks later infestations were 5 eggs and nymphs per sq. cm. in both sprayed and unsprayed treatments.

The mean yield of the sprayed tenancies at Wad Naaman was 2.22 k.p.f. against 1.81 k.p.f. from the unsprayed, an increase in yield of over 22 per cent.

At Fahl treated tenancies gave an average yield of 2.59 k.p.f. against 2.60 k.p.f. for untreated cotton. Spraying in Fahl did not begin until December (as opposed to November in Wad Naaman), when whitefly numbers were already declining rapidly, and the severe early infestation of fleabeetle, thrips and, in some tenancies, jassids had severely hindered crop growth. The only crops which showed vigour were those which had been sprayed early with DDT and it was these that responded best to parathion treatment as summarised in Table 13.

Table 13.

Response to parathion spraying in relation to date
of DDT spraying against jassids: Fahl Block. 1951/52
(in kantars per feddan)

			Date of D.D.T. spraying	Area sprayed with D.D.T	Mean yield	% increase Parathion/ Control
Parathion	...	...	1—14 Oct.	130	3.78	12%
Unsprayed	...	...		118	3.37	
Parathion	...	...	16—31 Oct.	50	2.31	1%
Unsprayed	...	...		50	2.29	
Parathion	...	...	1—15 Nov.	329	2.16	7%
Unsprayed	...	...		280	2.34	

These results though not accurate support the conclusions of the previous season that important increases in yield can be expected from control of whitefly in years of high infestations. Had the spraying been done earlier the increase in yield would probably have been much greater.

V. Insecticides.

TRIALS WITH VARIOUS INSECTICIDES.

The control of flea beetle by Schradan (as Pestox III) and by BHC — mercurial seed dressing (as Mergamma A) was attempted by application of the insecticides to the seed. In the case of Schradan it was shown that increasing the strength of the solution in which the cotton seed was soaked resulted in less of the solution being absorbed by the seed. There was a marked reduction in germination with increasing concentrations of Schradan. At 0.04 per cent Schradan, germination was 83 per cent (Control 82 per cent); at 1 per cent Schradan, 47 per cent and 5 per cent Schradan, germination was nil. There was also a marked reduction in the size of the seedlings with increasing concentrations. The treated seed showed no measurable toxicity to flea beetle. With BHC-mercurial seed dressing germination was found to be retarded only at the highest concentrations; the results are summarised in Table 14.

Table 14.
Effect of BHC-mercurial seed (Mergamma) dressing
on germination of cotton seed and survival of
P. puncticollis.

No. gms. Mergamma per 100 gms. seed	% germination after 21 days	Av. length of seedling after 21 days. (mm.)	% death of 50 flea-beetles after 48 hours on day old seedlings.
0.0	67	120.3	0
0.2	69	122.4	6
1.0	81	97.0	8
5.0	84	53.0	10
25.0	39	18.6	24

It was concluded that the degree of control was too small to be of practical value.

Seeds were also treated by soaking in solutions of varying strength of Pestox III, Isopestox, Pestox 14 and CR 686 (proprietary insecticides supplied by Messrs Pest Control Ltd.) and the subsequent seedlings allowed to become infested with *Hercotrips fumipennis*. Very little control was achieved by any formulation, and germination was seriously affected.

The same four insecticides were sprayed by handsprayers on to cotton plants infested with *H. fumipennis* to compare their toxicity with that of DDT. The rate of application is estimated at 140 gals. per feddan. 100 per cent mortality was given after 7 days by Isopestox, CR 686, and Psylortox (25 per cent DDT emulsion) at concentrations 0.07 per cent, 0.033 per cent and 0.0175 per cent (or 1 lb., $\frac{1}{2}$ lb. and $\frac{1}{4}$ lb. active ingredient per feddan) respectively. The DDT spray gave a more rapid kill than the other materials.

In further experiments CR 686 was applied at three different rates to cotton infested by jassids and whitefly. A systemic action was established in the control of both pests. With the two higher rates of application the number of jassids remained at more than 90 per cent below the level of the control for 46 days. The same rates of application gave 80 — 90 per cent reduction in number of whitefly for 10-12 days.

Several experiments were carried out to compare the effectiveness against *E. libyca* of the following insecticides supplied by Messrs. Shell Chemicals :— DDT oil emulsion (Arkotine D 18), DDT oil bound suspension (Supona D), BHC emulsible oil (Arkotine B 25), BHC oil bound suspension (Supona B), Toxaphene emulsible oil (TP 821), Aldrin emulsible oil (Aldrex 2) and Dieldrin emulsible oil (Dieldrin 15). In the final comparisons DDT was applied at 1 lb., BHC at $\frac{1}{4}$ lb., Toxaphene at 2 lb., Aldrin at $\frac{1}{4}$ lb. and Dieldrin at 1/7 lb. active ingredient per acre. In spite of the interaction between treatments which inevitably takes place in small plot trials the results clearly indicated that DDT is the most effective insecticide for the cotton jassid.

METHODS OF APPLICATION OF DDT SPRAY.

Two experiments were carried out during November and December to determine the spray distribution obtained with 3 types of land machines and 2 types of aircraft on the cotton plants. The areas and machines used, were :—

Amara 9 (Fahl Block).

Treatment.

1.	"Bean 500" sprayer, 40' boom with down-pipes	...	...	...	...	33 gall/fed.
2.	"Bean 500" sprayer, 40' boom without down-pipes	...	...	...	...	33 gall/fed.
3.	Low Volume "Weedkiller" machine without down-pipes	...	...	...	...	10 gall/fed.
4.	Auster Aircraft	...	...	...	...	3 gall/fed.

Mahas 2 (Wad Hussein Block).

5.	Auster Aircraft	...	...	...	...	3 gall/fed.
6.	Helicopter.	...	...	...	...	3 gall/fed.

Each treatment (unreplicated) by each machine extended over 10 feddans, *i.e.* one hosha in the case of land machines, 5 angias in each of 3 adjacent hoshas in the case of aircraft.

DDT was applied at the rate of 1 lb. of technical DDT per feddan, and a copper salt (cuprous oxide) added at the rate of 0.25 kg. (Amara) or 0.1125 kg. (Mahas) (Equivalent to 0.5 kg. and 0.225 kg. "Perenox" respectively) per feddan.

Results were based on jassid mortality, leaf prints, and chemical analysis.

Jassid Mortality.

- (a) *Nymphs per 100 leaves.* Standard counts were made on 500 leaves per hosha, 1 day before, and at intervals after spraying. These are summarised in Table 15.

Table 15.
Comparison of methods of application
of DDT spray.
(Nymphs per 100 leaves).

Treat- ment No.	1 day Before	1 day After	14 days After	30 days After	Treat- ment No.	1 day Before	14 days After
1	102	0.6	0.2	0.6	6	372.8	4.4
2	124	1.4	1.2	1.2	5	382.2	1.1
3	183.2	2.4	0.2	0.2	Unsprayed		188
4	112.6	25.0	2.0	2.0			
UNSPRAYED.				18.2			

- (b) *Plant Diagrams.* 50 complete plants were examined in each treatment, and records made showing number of jassid nymphs on each leaf, and the position of the leaves on the plant. The leaves and jassids were then grouped, according to position on the plant, as top, middle, or bottom. Top leaves were regarded as those from the uppermost 5 nodes, middle leaves from the next 5 nodes, and bottom leaves from the lower remaining nodes (a variable quantity but on the average about 5 nodes).

It is possible to calculate from these counts, the nymphs per 100 leaves in each position on the plant and so compare the mortalities in each treatment. This is summarised in Table 16.

Table 16.
Comparison of methods of application
of DDT spray.
(Nymphs per 100 leaves).

Treatment No.	Position of leaves	1 day before spraying	1 day after spraying	14 days after spraying
1	Top ...	108	2.7	0
	Middle ...	85	2.8	0.2
	Bottom ...	73.8	2.4	0.4
2	Top ...	72.8	5.2	0
	Middle ...	69	3.8	0
	Bottom ...	99	3.1	0
3	Top ...	46.3	0.2	0
	Middle ...	54.1	0.4	0.2
	Bottom ...	51.6	0.2	0
4	Top ...	72.2	25.2	0
	Middle ...	73.4	23.2	0
	Bottom ...	86.4	23.6	0.1
5	Top ...	328		0.2
	Middle ...	392		1.8
	Bottom ...	386		0.9
6	Top ...	264		4
	Middle ...	251		3
	Bottom ...	235		2

These figures show :—

(i) That the kill with Auster aircraft is slower, during the first 24 hours, than with land machines. This is presumably due to the greater dispersion of droplets on the leaves and the longer time required for nymphs to acquire a lethal dose of DDT.

(ii) That there is little, if any, difference in the efficiency of the machines, under the conditions of the experiment. The nymph counts are in all cases very low 14 and 30 days after spraying.

(iii) The kill of nymphs on the lower leaves of plants, with all machines, indicates good penetration of the spray into the crop and deposition of droplets on the lowest leaves.

(iv) The drop in nymph population was not as great with Helicopter as with Auster. Conditions during the Mahas experiment, however, were not as good as with the Amara trial.

Leaf Prints.

Leaf samples were collected from each treatment 30 to 60 minutes after spraying and brought to the laboratories for examination. 50 leaves were taken from each of 3 positions (top, middle and bottom) on the plants in each treatment.

The distribution of copper on the leaves (which is assumed to be the same as that of DDT) was then determined using filter papers soaked in dithio-oxamide (rubeanic acid) solution.

Preliminary experiments at the G.R.F. indicated that copper sulphate would give a good print even at 0.1 per cent Cu. (at which concentration it is not phytotoxic to cotton), but cuprous oxide was finally used because of the very marked corrosion caused by copper sulphate to metallic spray equipment.

At Amara, where the concentration of cuprous oxide in the spray was high, the resultant prints were good in the case of the aircraft spraying but with the higher volume machines they were much poorer and direct comparison could not be made with the former. The prints obtained at Mahas 2 were poor and this was due, at least in part, to the lower concentration of copper used.

The area of filter paper covered by each print was measured in a photoelectric absorptiometer. Results for the aircraft sprayed plot at Amara 9 are as follows :—

Per Cent of Leaf Covered by Spray

Leaf Position	Upper Surface of leaf	Lower Surface of leaf
Top	18.8	16.4
Middle	21.0	15.5
Bottom	13.6	10.6

These figures confirm the jassid nymph counts in that an appreciable quantity of spray reaches the lowermost leaves, and even their lower surface, with aircraft application.

Chemical Analysis for Copper.

Leaf samples, taken as the "leaf print" examination were analysed for total copper content by Messrs. Pest Control Ltd. Results are shown in Table 17.

Table 17.
Recovery of copper from sprayed plants.

Treat- ment No.	Position of leaves	100 leaves g.	Total Cu mg.	Amount D.D.T. corres- ponding to Cu deposit mg.	Approx area 100 leaves sq. cms.	D.D.T. Sq.cm. mgms.
1	Top	46.0	4.92	10	7300	.0007
	Middle	53.7	18.82	38.4	7400	.0026
	Bottom	22.0	11.28	23	7400	.0015
2	Top	50.2	4.53	9.25	"	.0007
	Middle	56.8	14.95	30.5		.0021
	Bottom	25.2	6.86	14.0		.0010
3	Top	60.1	10.87	22.2	"	.0015
	Middle	35.9	14.42	29.4		.0020
	Bottom	19.8	7.07	14.8		.0010
4	Top	57.2	4.15	8.5	"	.0006
	Middle	51.7	13.68	27.9		.0019
	Bottom	26.7	6.89	14.05		.0010
Unsprayed	Top	45.4	0.79			
	Middle	67.0	1.27			
	Bottom	27.2	0.82			

x. 1 gm. Cu = 2.04 g. D.D.T. o One side of leaf only.

It is possible to calculate from these figures, the amount of DDT per 100 leaves, and knowing the approximate area of leaves, obtain a rough estimate of the amount of DDT, in mg/sq. cm. deposited. This has been done in the table above.

It will be seen that :—

- (i) An appreciable quantity (up to 31 per cent in treatment 1) of the total DDT on the leaves reaches the lowermost leaves of the plant.
- (ii) There is little difference in deposit given by the different machines used in the experiment.

At Mahas 2, control leaves showed a very high deposit of copper and results from this experiment have been disregarded.

PHYTOTOXICITY OF INSECTICIDES FOR LOCUST CONTROL.

Experiments were planned in the use of aircraft for locust control primarily in Tokar Delta. Phytotoxicity trials were therefore carried out on cotton and dura using aircraft to determine which insecticides would be safe to use on crops. The trial on the locusts had to be abandoned as they did not appear. The results of the phytotoxicity trials are summarised in Tables 25 (cotton) and 26 (dura).

Table 25.

Phytotoxicity trials with certain insecticides
on irrigated cotton.

Application was made at a rate of 2 gals. of mixture per feddan in all experiments by means of a Hiller Helicopter.

Experiment	Insecticides	Dilution with water	Gallons (lb.) of active ingredient per feddan	Effect on plants
1	Toxaphene	Nil	1.30 (21.6)	Much spotting of leaves.
2	50% in miscible oil.	1 : 3	0.30 (8.0)	Noticeable spotting.
3		1 : 15	0.10 (1.7)	Very little spotting.
4	B.H.C. (10% gamma) in miscible oil.	Nil	0.24 (2.4)	Some dead patches on leaves
5		1 : 3	0.06 (0.6)	Noticeable spotting.
6		1 : 15	0.017 (0.2)	Very little spotting.
7	D.N.O.C.	1 : 3	0.11	10% of plants dead.
8	20% in miscible oil.	1 : 15	0.04	Serious defoliation.
9		1 : 64	0.01	Many dead patches on leaves. Little defoliation.

Table 26.

Phytotoxicity trials on irrigated dura.

Application was made at a rate of 2 gals. of mixture per feddan in all experiments except No. 1 when 4 gals. per feddan were applied. All applications made by Auster Aiglet aircraft.

Experiment.	Insecticides	Dilution with water	Gals. (lbs) of active ingredient per feddan	Effect on plants
10	Toxaphene	None	1.47 (24.4)	Severe spotting of leaves.
11	50% in miscible oil.	1 : 1	0.50 (8.3)	Slight spotting.
12		1 : 7	0.07 (1.2)	No damage.
13	B.H.C. (10% gamma) in miscible oil.	None	0.10 (1.0)	Severe spotting and discolouration.
14		1 : 3	0.04 (0.4)	Slight spotting.
15		1 : 15	0.01 (0.1)	No damage.
16	D.N.O.C.	None	0.32	Leaves all dead after 7 days.
17	20% in miscible oil.	1 : 3	0.07	Leaves all dead after 14 days.
18		1 : 15	0.02	Leaves severely spotted.

NOTES :— Toxaphene : ex Pest Control Ltd. Acrodel & DNOC : ex Plant Protection Ltd. The equivalent dose in lbs. is shown in brackets in column 4.

Assessment of damage was carried out by the Senior Botanist of the Research Division, but final yields of the crops were not taken. In the case of dura the crop was in the milky stage at the time of spraying and it is very unlikely that yields were affected by toxaphene or Acrodel. The high dosages of DNOC (experiment 16 and 17) caused comparatively rapid death of the plant. Since the heads dried out, and the yields could not have been seriously reduced. The average yield per feddan from the 9 plots sprayed was the same as from the unsprayed part of the field. The cotton was sprayed when about 6 weeks old, before coming into flower. None of the dosages of toxaphene or Acrodel had any prolonged effect on the plant and yields from these plots were considerably greater than the average yield on the Gezira Research Farm.

The DNOC treated plots (experiments 8 and 9) were severely damaged, but recovery was remarkably quick. After 2 months it was impossible to tell which plots had been sprayed with DNOC. Yields from experiment 7, however, are estimated to have been reduced by about 10 per cent on account of plants having been killed outright.

It is concluded from these experiments that benzene hexachloride (10 per cent gamma) and toxaphene can be applied safely to irrigated cotton and dura at dosages which may be expected to give a good kill of adult desert locusts. DNOC applied at rates which are known to kill locusts killed both cotton and dura. Serious though transient damage was suffered by these crops at lower dosages of DNOC, but it is possible that these lower dosages will give an adequate control of adult locusts.

CONTROL OF TREE LOCUSTS (*ANACRIDUM WERNERELLA*, WLK.)

The tree locust is a pest of gum (*Acacia senegal*, Willd.) in the Sudan and from time to time invades cotton crops and irrigated gardens in swarms which cause severe defoliation. Trials in control of these swarms by drift spraying were carried out by W. S. Richards.

Mystifier type 'LO'. Sprayer.

The sprayer was mounted on a lorry and the single spray lance directed into the air the spray being allowed to drift in a 10 mph wind. Agrocide wettable powder (containing 6.5 per cent gamma BHC) was used as a 3 per cent solution of gamma BHC in water. Estimated dosage was 0.35 lb. gamma BHC per feddan over an area of 10 feddans. A 3 per cent kill was estimated after 24 hours: any later kill could not be estimated as many of the locusts moved from the area.

Weardling Mark 1 Sprayer.

This sprayer was built to the specifications of D.L. Gunn and was first used in the Sudan in 1950. The machine was mounted on a lorry, the mast carrying up the spray to a height of 20 ft. into a 10 m.p.h. wind. An effective swathe width of 75 yds. was estimated. Dosages of

Acrodel estimated at 2 lbs. of gamma BHC per feddan applied as a mixture of equal parts of Acrodel and paraffin gave almost complete control. Toxaphene (50 per cent in oil) diluted similarly and applied at an estimated dose of 5 lbs. of active ingredient per feddan gave virtually no control. Garden plants suffered severe scorch from these dosages of both insecticides.

COCKCHAFER GRUBS (ADORETUS SP.) ATTACKING LUBIA.

A field experiment, designed to test BHC against cockchafer grubs was carried out at the G.R.F. on September-sown lubia in a four-course (D-L-C-F) rotation.

Five treatments, each replicated 5 times over a 5 feddan plot were used :—

	Treatment	Rate per feddan	Amount gamma isomer per feddan
1.	NIL		
2.	0.45% gamma — B.H.C. dust.	5 lbs.	10.2 gms.
3.	„ „ „ „	10 „	20.4 „
4.	„ „ „ „	20 „	40.8 „
5.	B.H.C.—organo—mercurial seed dressing	1/3rd „	27.0 „

With the exception of Treatment 5 which is a seed dressing, the insecticides were applied by means of small spatulas to the plant-holes at the time of sowing.

Preliminary tests on the phytotoxicity of the materials showed the BHC .45 per cent dusts to cause reduction in germination and growth rate of lubia at 50 lb/feddan, while at 100 lb/feddan, germination was completely inhibited.

Results were assessed on yields, however, one estimate of damage being made when the crop was 6 weeks old (age when harvested-20 weeks) : 1100 plant-holes were examined per treatment, and percentage of damaged or destroyed holes recorded.

Treatment	1	2	3	4	5
% Holes damaged or destroyed 6 weeks after sowing ...	40	6.54	6.54	4.81	20.9
Yields (Fresh weight in rolts per feddan)	1883	6731	8137	7645	2997

There is no significant difference between treatment 1 and 5, or between 2, 3 and 4. There is, however, a significant difference between the two groups.

The low yield of treatment 5 is probably correlated with the small quantity of dust used and its failure to spread through the soil around the roots. However, the marked increase in yield obtained with the other BHC treatments offers a simple and effective means of controlling cockchafer grubs on lubia.

VI. The Ecology and Control of the Grasshopper.

Aiolopus savignyi, Kr.

The first showers of rain in 1951 in the Gedaref area fell in April, and conspicuous flights of *Aiolopus* were recorded in several localities in the district in late April and May. Concentrations were recorded only in areas which had recently received rain. By the end of May *Aiolopus* was well distributed over most of the southern part of the Gedaref district, and flight at sunset until 2 hours later was commonly observed. Rainfall during June and July was extremely light and breeding was recorded in only one or two well watered spots. *Aiolopus* was virtually absent from the belt of dura cultivation (*i.e.* south of the 500 mm. isohyet) during August.

In the Butana, which lies north of the 500 mm. isohyet, rains were erratic and local throughout the season. In early May, following light showers, flights of *Aiolopus* were observed in several areas in the Butana but no breeding was recorded until late July when dense congregation of young adults in addar grass (*Sorghum* sp.) in certain areas led to the conclusion that two generations had been completed in these localities. An important characteristic of these localities was that they received the run-off of rain water from surrounding low hills. Further breeding was observed in September but the addar grass, which was now over 6 feet high, was abandoned and large numbers of nymphs and adults were found in areas of *Brachiaria lata*, Schumacher and Hubbard, *Urochloa trichopus*, Stapf. and *Setaria pallida* — *fusca*, Stapf. and Hubbard, all of which are tall grasses though *Setaria* grows in widely spaced clumps. Nymphs and adults were also found in open mats of the short grass *Aristida hordacea*, Kunthe. Unweeded cultivations provided a concentration ground for adult *Aiolopus*. Here the vegetation consisted largely of the short grass, *Heteropogon contortus*, Roem. and Schult. and *Ocimum americanum*, L. (Labiatae). Density of vegetation appeared to play no part in concentrating adults of *Aiolopus* which were found in the open vegetation of fallow land and in low dense mats of *Panicum hygrocharis*, Stend. as well as in the vegetation types mentioned above.

Rains ceased in early October and vegetation began to dry out. Uniform drying out resulted in the dispersal of adults and in October it was possible to distinguish:—

- (i) Virtual concentration in a variety of vegetation types where drying out had been uneven.

(ii) Real concentration in areas where water receipt from run off had produced conditions particularly suited for breeding.

(iii) Scattered populations over wide open spaces of grassland.

Movement of *Aiolopus* southwards into the areas of dura cultivation began in mid-October when the north wind started. Migration of swarm numbers was commonly observed at sunset on evenings when the air was still and flight apparently stopped when the wind began to blow, usually some two hours later. Solitary adults tended to fly south as well as swarms.

Large areas of dura in the Gedaref district were invaded and some serious damage to grain took place; as in previous years damage was most severe to crops that were already suffering from water strain.

VII. Status of Cotton Pests in Tokar Delta

Economic Status of Insect Pests.

Observations were made of about 80 cotton plants in preselected and specially sown sub-plots in Tokar delta. The sub-plots included the following treatments.

(1) Edge and centre plants on:—

- (i) Plots surrounded by a dura wind break.
- (ii) Plots surrounded by a dukhn wind break.
- (iii) Plots surrounded by a *Cajanus* wind break.

(2) Intersown with bamia.

In all observation plots some plants were sprayed at weekly intervals with a BHC preparation which kills *Creontiades pallidus* but not *Heliothis*.

The following conclusions were reached:—

- (i) More fruiting points were damaged near dukhn than dura.
- (ii) Most damage was within 20 yards of the wind break.

Before harvesting of dura, *Heliothis* damage seemed to decrease and *Creontiades* damage to increase within distances up to 20 yards from the wind break.

Biology of Heliothis armigera.

Solanum dubium is suspected of being important in the carry over of *Heliothis* during the dead season for cotton.

Dukhn foliage was more constantly infested than dura foliage and must be regarded as more attractive to gravid female moths. In crops egg-laying and subsequent infestation was greatest along the edge of the crop. Egg-laying was greatest just before the milky stage of both

crops. After this the grain crop was not attractive to gravid females which transferred their attention to cotton which by this time was in flower. Maximum egg-laying on cotton preceded the date of maximum flowering.

Closed headed dura seems slightly more attractive for egg-laying than open headed varieties and survival of larvae appears to be greater in the former.

Biology of Creontiades pallidus.

The bug has been found throughout the Red Sea littoral on dura and dukhn. It has also been found on a variety of other host plants. The life cycle has been more fully worked out and several previously unrecorded predators have been found.

Close and open headed dura varieties appear to be equally suited for egg-laying. There is no evidence that breeding is less on open headed varieties but dispersal of adults appears to be quicker than from close heads.

More heads are infested on the perimeter of a dura crop than inside.

Although breeding occurs on cotton this is not a satisfactory host plant, and numbers of *Creontiades* on cotton decline rapidly after the dura harvest.

The presence of a stain on shed fruiting points was found to be of little value in assigning the cause of shedding to *Creontiades*. During the fruiting season only 2, 6 and 2 per cent of buds, young bolls and well developed bolls respectively were shed in association with *Creontiades* stain.

Vegetative and fruiting behaviour of cotton.

Detailed observations on plant growth revealed no differential effect of good and bad land on production of nodes. Similarly it was found that node production was the same in cotton growing near and outside the shade of a windbreak although the former cotton was taller. Differences in node production, height and defoliation shown by cotton grown in well and badly watered parts of the delta were negligible.

Boll shedding was found to parallel the number of bolls present on the plant at any given time. Shedding appeared to be controlled by a mechanism internal to the plant and to be independent of but inclusive of any shedding which was associated with insect attack. In the case of *Heliothis*, for every boll shed in association with damage by this pest, 15 — 16 were shed from 'unknown' causes.

Other pests.

Six weeks after planting 2 — 12 per cent of the seedling plant-holes contained at least one plant whose terminal bud had been destroyed by the larva of *Earias insulana*. In damaged plant holes up to 40 per cent of the plants were thus blinded. There was no evidence, however,

that *Earias* could be regarded as an important pest of mature cotton although 2 — 3 per cent of the fruit points shed were shed in association with *Earias* attack.

Loss of bolls from *Platyedra gassypiella* was negligible until late March when 15 per cent of the mature bolls were recorded as damaged. But at the same time nearly 80 per cent of the mature bolls were being shed from unknown, presumably physiological causes.

It was established that termites (species undetermined) attacked healthy plants. By April an average loss of 21 per cent of plants were found to have been destroyed in a sample of 12000 plants. The loss of crop from termites is estimated at about 25 per cent.

VIII. Desert Locust Survey

The present season saw the inauguration of the Sudan Desert Locust Survey, an organisation planned in 1948 as the Sudan contribution to investigations undertaken by the East African Desert Locust Survey. The absence of swarm breeding made it possible for the survey to concentrate during the winter on outbreak centres on the Red Sea littoral. Preliminary reconnaissance in November 1951 revealed a high population of solitary locusts in the vicinity of Karora, but few were found along the rest of the coast. Investigations were therefore concentrated on a site near the Eritrean frontier. In this area two generations were completed during the winter but these overlapped so that both hoppers and adults could always be found between January and May. The early hoppers showed solitary colouration but in February markings associated with gregarious behaviour were found. In some places and marching bands were formed. This did not always seem to be associated with cultivation.

Detailed observations were also made on certain selected concentrations in which daily capture and marking was carried out in order to develop a technique for estimation locust populations.

IX. Control of Pests

DESERT LOCUST.

The first locust activity of the season was during the second half of June when 5 sexually immature swarms were reported in Darfur. In July and August an increasing number of swarm reports were received but by the last week in August the numbers had begun to decline. No egg-laying was reported but in early September hatching occurred in Khartoum Province on a very small scale. In Kordofan scattered hoppers showing markedly solitary characteristics were found later in the month. No further invasion of summer-rain breeding areas occurred during 1951. All hopper infestation was destroyed in the first instar by baiting.

No invasion of the Red Sea littoral occurred until the end of February 1952 when 3 reports of swarms of immature adults flying high in a north westerly direction in the vicinity of Karora, on the Eritrean frontier, were received. This was doubtless a part of the northerly displacement of swarms originating in the Somali Peninsula in 1951 which apparently resulted in the invasion of north-east Saudi Arabia, Iraq and Iran in March and April 1952. In any event the Karora swarms were not seen again in the Sudan.

A large scale invasion of the Sudan had been expected, and in order to obtain early information of immigrants, oviposition and breeding, teams of scouts supported and organised by motorised units were out in the field in early June. In the absence of egg-laying the campaign was closed down in most parts of the country by mid-September. In November scouting began on the Red Sea littoral, and continued until early February when operations were concluded.

Exploration of the Libyan Desert.

The desert area north of the 16th parallel in the western Sudan is regarded as being too dry for locust breeding, but in 1950 when unprecedented rains fell in the northern Sudan there was good reason to suppose that breeding might have taken place within that part of the Libyan Desert lying within the Sudan frontiers. It was not possible to mount an expedition in 1950, but in 1951 advantage was taken of the absence of breeding to try and find out what had happened during the previous year, and to explore the means of approach to these difficult regions. A preliminary reconnaissance was carried out in July by two senior Sudanese officials who found definite evidence of breeding between the 17th and 19th parallel from Jebel Tagaru (16.00 x 27.15) and Rahib wells at the mouth of Wadi Hawar (17.45 x 27.00). Subsequent more detailed surveys were made by 3 teams led by officers kindly loaned by the E.A. Desert Locust Survey.

The three expeditions were successful in their objectives and collected valuable information, although dust storms had obliterated all evidence of 1950 breeding. The following are the main conclusions :—

(i) Reconnaissance of the Sudan Libyan Desert presents no difficulty to properly organised expeditions equipped with modern desert-worthy transport.

(ii) Control teams could operate in the area but the long lines of communication would make it necessary for them to be self contained and operate as an expedition. Water supplies are adequate.

(iii) Breeding was probably on a considerable scale in 1950 in Wadi Howar and in the area to the south. In 1951 almost no rain fell north of the 16th parallel and no locusts were seen.

WEAVER BIRDS (*QUELEA QUELEA AETHIOPICA*).

Dry Season Roosts in 1951.

The swarms still present in the Blue Nile region at the conclusion of the explosives campaign in the 1950/51 season are shown in Table 18 where roosting sites of other years are included for comparison.

Table 18.
Dry Season roosts of *Quelea*

Region		No. of roosting sites (Jan.—April)					
		1947	1948	1949	1950	1951	1952
Blue Nile	Blue Nile ...	9	21	6	2	3	22
	Dinder... ..	4	—	—	2	14	} 16
	Khor Atshan	—	2	7	—	2	
	Rahad	6	1	6	2	—	6
TOTAL ...		19	24	19(11)	6	19(6)	44(7)
White Nile	Kosti-Galhak		—	—	10	9	6
	Galhak-Malakal	Date	—	—	7	5	2
	Kosti-Miteimir	not	—	—	5	3	1
	Miteimir-Kodok	avail-	—	—	14	5	8
	Kodok-Tonga	able	—	—	5	4	1
	Khor Yabus		—	—	6	—	—
TOTAL ...			—	—	47	26	18

(Numbers in brackets indicate swarms destroyed by blasting)

Of the swarms which roosted in the Blue Nile region during the 1950/51 dry season those which escaped destruction by blasting remained by the rivers until mid-July 1951, this delayed dispersal being attributed to the lateness of the rains. By mid-August swarms had been reported from 17 localities from Jebel el Geila (14.59 x 35.54) in the north, to Khor Simsim (13.03 x 35.00). Absence of swarm reports to the south of the 13th parallel is attributed to lack of adequate scouting arrangements. Eastward dispersal continued during the second half of the month when the birds were first reported in the vicinity of Kassala. Considerable mortality occurred during this period, caused no doubt by the absence of food due to the lateness of the rains.

No reports are available from the White Nile region on the dispersal of swarms during the rains. Villagers questioned in February 1952 said that swarms were seen in May in the vicinity of Boing (9.58 x 33.44) and Kurmuk. In May also swarms are said to have visited El Obeid.

No damage to crops was reported during the dispersal period.

Nesting Colonies 1951.

Nesting began in the Singa area between 4-8 September, egg-laying between 9-13 September and hatching 25-28 September. Young had left their nests by 14 October. Data are not available for the other areas.

The area covered by nesting colonies is shown in Table 19, where data for other years is included for comparison. These figures are

necessarily very approximate. 178 and 213 probably do not mean a real difference but the difference between 23, 200 and 5000 must mean real differences.

Table 19.
Quelea nesting colonies in square
km. of bush containing nests.

Area	Estimated size in square kilos.					
	1946	1947	1948	1949	1950	1951
W. Blue Nile ...	244	—	—	—	4	116
E. Blue Nile ...	—	12	9	—	—	62
Dinder ...	—	—	—	—	—	—
Rahad ...	—	—	—	—	—	—
Gedaref ...	1219	—	—	7	18	—
Atbara—Kassala ...	3307	1400	—	16	58	—
Eritrea (x) ...	720	—	2	—	133	Heavy nesting.
Ethiopia (x) ...	N.A.	—	—	N.A.	At least ‡	None reported.
TOTAL ...	5490	1412	11	23	217	178 + Eritrea

(— is nil)

(x) Frontier areas.

(N.A. no investigation made).

No nesting on the scale recorded in 1946 has been recorded since, although the 1951 dry season roosts were comparable in number and size to those of 1947 (before blasting). In 1951 the rains were poor and very late. The swarms which were reported in the north (Khashm el Girba — Kassala vicinity) in August disappeared in early September without nesting. At the same time swarm reports from the south increased and when Eritrea was visited in September, nesting was found to have taken place on a considerable scale.

An examination was made of the fertility of birds nesting in the Blue Nile region, by counting the numbers of nests per tree and number of eggs per clutch. The results are summarised in Tables 20 and 21.

Table 20.
Quelea. Eggs per nest.

Year	Locality.	No. of nest with ' n ' eggs/nest							Nests per tree	No. of trees.
		0	1	2	3	4	5	6		
1951	Singa Area.									
	Locality 1	—	8	34	180	11	2	x	235	Mean from 5 trees.
	„ 2	—	9	22	170	11	1	—	212	
	Dinder Area.									
	Locality 1	3	10	27	194	12	2	—	248	
	„ 2	8	10	38	184	9	4	—	253	
1951	Khor Atshan.									
	Locality 1	—	11	24	196	7	1	—	239	
	„ 2	—	8	21	186	17	2	x	234	
	Mean	2	9	27	185	11	2	x	236	
1949	Doka 1	87	47	46	24	9	x	x	213	Mean of 10 trees except Gedaref 1 where mean of 6 trees.
	„ 2	23	17	30	38	17	1	x	125	
	„ 3	67	19	27	38	8	1	x	160	
	Hawata 1	106	28	55	180	43	5	2	419*	
	„ 2	80	16	33	52	11	2	x	194*	
	Mean	73	25	38	66	18	2	x	222	

* 3 nests in 10 trees had 7 eggs.

2 nests in 10 trees had 8 eggs.

x represents less than 1.

Table 21.
Fertility of Quelea

Year	Average No. nests/tree	Average No. eggs/nest All nests	Average No. eggs/nest Nests with eggs	Percentage hatching (1)
1949	222	1.1	2.5	not known
1951	236	2.1	2.1	96

(1) Based on observation of contents of 30 nests.

Villagers destroyed nests near cultivations in 1951 but many nesting sites were not destroyed. Some damage to dura and dukhn was reported in the Fung district during September, namely during nesting. During October parent birds and progeny which had bred in the Blue Nile region were reported as follows :—

Singa and Dinder areas 2 swarms; Khor Atshan area several (not more than 6); Hawata area no sizeable swarms; Doka and Atbara-Kassala areas were free. No serious damage was reported. A visit to the frontier districts of Eritrea confirmed that nesting and hatching had been on a large scale but in Ethiopia breeding did not appear to have taken place.

Autumn Migration 1951.

During the first week of November, nesting areas in the Blue Nile region were abandoned and congregation in large swarms on suitable drinking sites began. 4 such concentrations were located in this theatre, all in the Singa area. This concentration continued in December, when increased numbers of swarms were reported in the Singa, Dinder and Hawata areas.

No damage to dura occurred during the autumn migration in the Blue Nile region. In the White Nile region information on swarm movements is very sparse and unreliable but severe damage was reported in the Paloich area, its extent is unknown.

Dry Season Roosts and Blasting Campaign 1951/52.

The 1953 dry season roots are summarised in Table 18. In Table 22 the monthly swarm reports are tabulated to show the build up of swarms during this period and their movements.

Table 22.
Dry season 1952 : Swarm reports of Quelea
Nos. of swarms reported.

Area	Nov.	Dec.	Jan.	Feb.	March	April
1. Singa	5	6	10 (1)	12 (1)	11	11 (1)
2. Dinder	2	5	9 (2)	7 (2)	5	5
3. Khor Atshan ...	4	9	11	13	13	13
4. Hawata	—	—	2	4	6	6
5. Doka	—	—	—	—	—	—
6. Atbara—Kassala ...	—	—	—	—	—	—
Total live roosts ...	11	20	32	36	35	34
Total roosts blasted ...	—	—	(3)	(3)	—	(1)

(Nos. in brackets indicate roosts blasted during that month).

Total live roosts in Blue Nile region at the end of April was 33.

In May and June 4 more swarms arrived in the region.

It will be noted from Table 22 that the number of swarms increased in the Blue Nile region until February. After February only 2 more appeared on the Rahad. In May and June, 3 more reached the river Blue Nile and 1 the river Dinder giving, by June, a total of 44 swarms present in the area, as indicated in Table 1.

A total of 30 tons gelignite were provided for the blasting campaign. Since all the necessary Cordtex fuse failed to arrive it was not possible to use all the explosives and 282 boxes were returned to Khartoum at the end of the campaign. A total of 918 boxes (26 tons) were used. A total of 10 of the roosting sites were blasted; 7 in the Blue Nile and 3 in the White Nile regions.

MISCELLANEOUS.

PINK BOLLWORM. Routine inspections of ginneries in the Gezira and Nuba Mountains were carried out as usual. Sunning of cotton seed was also carried out at Zeidab, Tokar, Khartoum and in the Nuba Mountains. The seasonal inspection of riverain cultivations was made in the vicinity of the Gezira Scheme with a view to preventing the growth of bamia (*Hibiscus esculentus*) during the prohibited period.

COTTON FLEA-BEETLE. The campaign in the Gezira this season was on a larger scale than in the past season. As usual the the power duster was used with effective results. The total acreage treated was 7503 and the total quantity of Agrocide used was about six tons.

COTTON STAINER BUG. The control area for the stainer bug campaign in the Nuba Mountains was extended, all the Jebels District being included. The campaign was organised by entomological staff assisted by the staff of the Field Division. The first round of the campaign began in mid-June and was finished by the end of July except that mopping up operations continued up to mid-August. The second round started early in September and was successfully concluded by the end of October. The total number of infested tebeldi trees treated was 1137.

COTTON THIRIPS. This section made no arrangements this season for combating the pest in the heavily infested areas of Abu Habil, Gedaref, Gash and Gondal. The authorities concerned made their own arrangements with commercial firms.

DURA ANDAT BUG. The dry season campaign against the dura andat was conducted in the same areas as last season and the methods employed were also the same. The campaign lasted from 1st March to 8th. July with successful results (over 90 per cent kill was generally secured). A total of 7.5 tons of Agrocide 3 was used.

MEALY BUG. In Khartoum and Northern Provinces destruction on the usual lines was continued against Hibiscus mealy bug (*Phenacoccus hirsutus*). In Kassala Province destruction of guava mealy bug (*Ferrisia virgata*) was carried out.

FIELD RATS. Campaigns were waged against rats in Northern Kassala and Blue Nile Provinces. The main bait used was dura soaked in arsenite of soda which gave successful results.

FRUIT FLY. The fruit fly campaign comprised two phases, protective and destructive. The first phase is the destruction of the pest on its main host plant, guava, so as to reduce the population migrating to alternate host plants or citrus. The second phase deals with the destruction of the pest on the citrus plants. Agrocide wettable powder was used as a spray.

X. PLANT QUARANTINE SERVICE.

The stations at Khartoum, Wadi Halfa and Port Sudan performed their functions. There is nothing of particular interest to report.

XI. RESEARCH ON BOLLWORMS IN THE GASH DELTA.

The River Gash which rises in Eritrea flows into the desert north of Kassala. The flood comes during the period July to September and the water is canalised and led on to the land where it lies for 20 to 30 days before drying up. The land is then sown with Egyptian cotton and dura. The area watered varies from year to year and the amount of cotton sown varies between 22000 and 72000 feddans. The 1st rotation is planted early in September, the 2nd. rotation late in September.

The average yield of cotton per feddan is only half that of the Gezira Scheme. Bollworms were often known to cause serious losses and it was considered that they might constitute a major cause of the poor yields. An investigation on bollworms was therefore begun by staff of Pest Control Ltd. who were seconded to the Research Division for this purpose. The objects were to elucidate the status of the bollworms as pests and to discover an economic method of controlling them. The bollworms concerned are the Sudan bollworm (*Diparopsis*), the Egyptian bollworm (*Earias*), the American bollworm (*Heliothis*) and the Pink bollworm (*Platyedra*). The two former are the most important.

STATUS OF BOLLWORMS.

It was decided to study the status of bollworms by means of plant diagrams which would reveal the fate of fruiting points and the losses caused by bollworms on untreated plants compared with plants which would be kept free from bollworms by the removal of all eggs before they hatched. Egg laying would also be recorded from the untreated plants. The other method to be used was random sampling in the crop. The plants to be studied were selected as follows. Six large cotton fields as widely separated as possible were selected, 3 being under Sakel Cotton and 3 under the variety X1730A these being the two varieties grown in the Gash. In each field 3 sites were selected arbitrarily and 2 plant holes in each chosen at random; each plant hole contained 3 plants.

Egg Counts and bollworm-free plants.

Owing to the light rains in 1951 there was very little growth of ratoon cotton in the Gash. In one area where observations were made on ratoons before these were pulled out it was noted that the plants were 3 weeks earlier than the crop. Here egg counts were as follows on 20 plants (*Diparopsis*).

Date	No. of eggs
9 October	94
13 "	77
17 "	52
21 "	125
26 "	94
Total	442

From the 36 plant holes of the crop egg counts (*Diparopsis*) were as follows :—

27 October	0
31 "	6
3 November	49
6 "	57
10 "	19
13 "	0
17 "	2
20 "	7
24 "	1
27 "	2
1 December	5
4 "	5
8 "	5
11 "	3
15 "	1
18 "	5
22 "	1
Total	168

The egg laying on the crop was thus much less than on the ratoons. 75 per cent of the eggs were recorded during the period 1-10 November but this relatively heavy infestation did not follow immediately after the counts on the ratoons. It seems probable however that it does represent the final stages of the same moth flight and that the delay in eggs appearing on the cotton crop was due to its not yet being advanced enough for oviposition. It is of interest that eggs could be found on the largest cotton plants when the crop in general showed very few.

Egg laying was at a very low level and eggs were more difficult to find than had been hoped. With the cotton growing rapidly the counts became very laborious and it is probable that a large proportion

were not detected. For these reasons and because of the urgency of other work egg counts were abandoned at the end of the year. Eggs of *Earias* were very difficult to find owing to their colour and small size and very few were recorded. Very few eggs of *Heliothis* were found.

For the above reasons the attempt to produce bollworm-free plants was not successful.

Shedding Data.

The plant diagrams give accurate data as to the number of buds and bolls shed at various times but do not reveal the cause of shedding. Collection of sheds from the ground gives the cause of shedding but the numbers are not accurate per plant as the sheds get blown about. The figures given below are from a combination of the two sets of data.

Cotton in the sites studied was sown about the end of August but one site was sown on 23 September. Nevertheless bud production began between 30 October and 9 November in the early-sown and on 4 November in the late-sown cotton.

The maximum periods of production of buds, flowers and mature bolls are given in Table 23.

Table 23.
Maximum Production of Fruiting points.

Maximum Produc- tion of	X1730A		Sakel		Average	
	Av. Date	No. of Days from planting	Av. Date	No. of Days from Planting	Av. Date	No. of Days from Planting.
Buds ...	21 Dec.	112	7 Dec.	91	14 Dec.	102
Flowers	7 Jan.	129	7 Jan.	122	7 Jan.	126
Mature Bolls ...	7 March	189	7 March	182	7 March	186

Table 24 shows the cumulative monthly totals of fruiting points produced per plant and the numbers shed. The ratio of shed buds to shed bolls was 4 to 1.

Tables 25 and 26 show the causes of shedding.

Table 24.

Month.	X 1730 A (1st. Rotation)			Sakel (2nd. Rotation)			Average of both varieties.		
	No. fruiting Points	No. Shed	Percentage Shed	No. fruiting points	No. Shed	Percentage Shed	No. fruiting points	No. Shed	Percentage Shed
October	0	0	0	6	0.4	8	3	0.2	0.8
November	33	6	18	37	10	28	35	8	23
December	68	18	26	66	18	28	67	18	27
January	127	60	47	95	44	47	111	52	47
February	127	78	62	95	52	55	111	65	59
March	127	88	70	99	55	56	113	72	64
April ...	127	90	71	100	58	58	114	74	66

Table 25.
Monthly Production of fruiting points and shedding
Average both varieties.

	No. Fruiting points produced	Total No. shed	Number of sheds caused by		
			Diparopsis	Heliothis	other causes
October	2.9	0.22	0.18	0.0	0.04
November	32.35	7.85	4.55	0.12	3.18
December	31.75	9.9	1.93	1.24	6.73
January	43.77	33.92	6.95	7.80	9.17
February	0	13.2	2.8	2.5	7.9
March	2	6.5	1.62	1.37	3.51
April	0.8	2.66	?	?	?

Table 26.
Cause of shedding.
Expressed as percentage of total sheds during the season.

Month			Diparopsis and Earias	Heliothis	Other Causes	Total
October	...	...	0.16	0.0	0.03	0.19
November	...	...	2.7	0.1	1.9	4.7
December	...	...	5.3	3.5	17.5	26.3
January	...	...	6.4	6.9	17.4	30.7
February	...	...	4.0	3.6	10.9	18.5
March	...	...	5.0	4.2	10.6	19.8
Total			23	18	58	100

The data from sheds on the ground has been adjusted in time to fit the plant diagram data since the latter referred to fruiting points which were collected from the ground later.

Sheds attributed to *Diparopsis* and *Earias* have been put together since the characters distinguishing them are not considered reliable. Pink bollworm was too uncommon to matter.

It will be seen that shedding started to be considerable in November and rose to a peak in January. Shedding due to *Diparopsis* (and *Earias*) was highest in November and January, while that caused by *Heliothis* was less except in January, the month of maximum flower production. Shedding due to other causes increased with the production of fruiting points and was always greater than that attributed to bollworms. Cotton plants always shed a large number of the fruiting points which they produce and it is possible that the comparatively small number of sheds attributed to bollworms would have been shed by the plant anyway, perhaps owing to water shortage which becomes more or less acute in the Gash Delta as the season advances. The bollworm attack in the 1951/52 season was however considered to be lighter than usual.

Random Sampling in the crop.

The method finally adopted was to strip all buds, flowers and bolls, from a number of plants, which had been selected at random, and examine them in the laboratory. The sampling was done over as wide an area as possible.

The total loss of crop due to bollworms given by this method, about one quarter, was similar to that deduced from the plant diagram data.

The random sampling showed the number of larvae present per feddan and it is interesting to note that the population of *Diparopsis* and *Earias* was at its highest in April.

BIOLOGY OF BOLLWORMS.

DIPAROPSIS PERDITOR, CLEMENTS.

Resting stage.

The soil of several fields which were said to have been heavily infested by *Diparopsis* in the previous season was sampled to ascertain the number of pupae present and the depth of pupation.

Samples of soil 1 metre square and 12 cm. in depth were taken at random and the two 6 cm. steps examined separately. A dry and a wet method of examining the samples were tried neither of which proved satisfactory and both of which were very slow.

In the time available only 2 fields could be examined. In one of these no pupae were found and in the other three in the top 6 cm.

Annual moth flight including the carry-over flight.

The annual moth flight cannot be arrived at directly but can be inferred by collecting 5th. instar larvae at intervals throughout the season, allowing them to pupate and recording the emergences. This will give an estimate of the moth flight and the proportion of larvae forming long-cycle pupae as the season advances; the moths which emerge from the latter will constitute the carry-over flight. Unfortunately the population in the field was too low to enable a reliable estimate to be made, though some data was obtained on the carry-over flight.

Another method is by recording catches from light traps, but this method suffers from serious disadvantages. It is known that such catches are not representative of the population, more males being attracted to light than females, and larger catches are made on moonless nights. In any event the numbers caught were too small for any conclusions to be drawn from them.

From the middle of February localised areas of cotton were found to be fairly heavily infested with *Diparopsis* and it was possible to obtain sufficient numbers of larvae for recording their pupation and emergence. Table 27 gives the results.

Table 27.
Emergence of *Diparopsis* moths.

Date of Pupation	No. of Pupae	Date of Emergence	Pupal Period (days) (approx)	Percentage Emerging
21—27.2	67	10—16.3	18	18
28.2—5.3	74	18—25.3	20	58
6—12.3	163	21—30.3	16	33
13—18.3	58	29.3—4.4	15	17
20—26.3	54	4—10.4	14	28
27—30.3	18	12.4	14	11
5—9.4	37	28.4	21	3
10—17.4	93	29.4—1.5	17	13
20—26.4	24	13.5	21	4
26—30.4	20	No more moths emerged up to the end of May.		
6.5	17			
11.5	18			
15.5	3			

Assuming that there was no large mortality among the pupae, which will not be evident till next season, it appears that long cycle pupae were already being produced when the experiment began towards the end of February. The number of long cycle pupae increased after 26 March.

Habits of larvae.

A number of observations have been made on the habits of larvae and the findings utilised in the designing of experimental techniques for the testing of insecticides.

Eggs of *Diparopsis* normally hatch in the morning between the hours of 5 and 7; at no time have eggs been observed to hatch during the heat of the day or in the evening. The larvae on exclusion from the egg, commence wandering in search of food, be it a bud, flower or boll. The length of this period of initial wandering depends greatly upon the length of time a newly hatched larva is able to live without food, and the placement of the egg.

Without food, first instar larvae do not appear to live very long. In the field they rapidly die when exposed to direct sunlight. Larvae taken out into the field for infesting plants do not live for more than 2-3 hours, and it was found that unless the infestations were carried out before 8 a.m. the larvae died or were too weak to effect a penetration. It is at about 8 a.m. that the air temperature begins to rise rapidly and the sun begins to fall directly upon the plants. It would seem therefore, that if larvae are to survive they must find a fruiting point fairly quickly.

Before describing the effect egg placement has on larval survival, it is necessary to describe in what ways distribution of larvae may occur. There are two methods of distribution, only one of which has been observed in the field. The larvae may crawl over the plant in search of food or they may distribute themselves by hanging from the plant on a silken thread and being blown to a neighbouring plant. It is the former method of distribution only that has been observed in the field and is probably the normal one. The latter method has been observed in the laboratory when, on hanging up sheets of muslin containing eggs, the emerging larvae are seen to hang in festoons, supported by a thin silken thread. It must be supposed that this method of distribution does occur in the field.

It is obvious that the length of time a larva spends in wandering will greatly depend upon the placement of the egg. Several experiments have been carried out, the results of which are given below :—

- (a) Eggs placed on the inside of bud bracts. In all cases the bud in question is penetrated rapidly by the emerging larva, and little wandering takes place exposing it to external conditions.
- (b) Eggs placed on the outside of bracts. In all cases the bud in question is penetrated rapidly by the emerging larva, and little wandering has been observed to take place, although slightly more than in (a). Again the larva is exposed to external conditions for only a short time.
- (c) Eggs placed on the terminal leaves of sympodia, the leaves of which possess axillary buds or bolls. In approximately 50 per cent of the cases, the larvae, after crawling down the leaf petiole, successfully penetrate the axillary buds. Again, not much wandering need occur.
- (d) Eggs placed on leaves present on the growing point of the main monopodial stem. With this placement, the larvae find it more difficult to gain a fruiting point. Most of the buds nearest the larvae will be very small. In one experiment, out of 16 eggs placed on growing points, only 6 emerging larvae successfully penetrated buds, and these buds, although very small, were the ones nearest to the egg.

In both sympodial and growing point placements, examination of the plant did not reveal that the missing larvae had penetrated any other fruiting point contained on it. Unless larvae are blown to another plant it would appear that heavy larval mortality can result from unfavourable egg placement.

On finding a bud a larva quickly effects penetration. The site of entry may occur at any place on the bud, but is usually restricted to that part which is in contact with one of the bracts. In this position, the larva spins a fine web connecting the bract to the bud, and penetrates the bud under its protection.

Direct observations of larvae penetrating a bud have been made and, as is reported by other observers, the outer tissues of the bud are rejected via the mouth in small pellets. A few larvae were followed into buds by carefully cutting away the bud tissues so keeping the larvae exposed. It was observed that rejection of tissue occurred for at least 24 hours after penetration, but whether this happens normally is open to doubt, as it is possible that a larva exposed to the light will attempt to penetrate deeper into the bud by rejecting plant tissue via the mouth. The first faecal pellets were observed 1 hour after penetration.

During the course of feeding on a bud, a larva will frequently clean frass from its tunnel by turning round and pushing the frass to the outside. During this operation the larva may leave the tunnel altogether and then re-enter it. While feeding, the anal end of a larva is often seen protruding slightly from the entrance of the tunnel.

The length of time a larva remains in a bud depends upon several factors, the most important being the length of time before the bud is shed. A medium sized bud will be shed approximately four days after penetration, while small bud may be shed after two days or sooner. If an infested bud is shed before four days, the larva usually remains in the bud until it dries up, after which it wanders in search of fresh food. On the other hand, a bud that is shed after four days may not necessarily contain a larva. The reason for this is that after the first moult, which normally occurs about the fourth day, the larva will often go in search of fresh food and will not re-enter the original bud. This moult may either occur inside the bud, or as has frequently been observed, on the outside of the bud protected by a fine cocoon. Once a larva leaves a bud it will tend to enter a boll.

It seems highly probable that a high larval mortality must occur at this stage of the larval life history, especially with larvae that are contained in shed buds. It has been observed that this mortality is influenced a great deal by the type of growth a cotton crop may have. Sakel cotton tends to have a prostrate habit of growth, the lower monoodia and sympodia tending to lie on the ground. During routine larval collections, one particular area of Sakel was found to be exceptionally prostrate, and the bolls which were lying on the ground were nearly always infested. Although no counts were made, it seems reasonable to suppose that the heavy infestation resulted from larvae leaving shed buds having a better chance of finding a boll upon which to feed.

The above observations have covered buds only. With regard to bolls, small bolls will shed after five to six days depending upon their size and in this respect are similar to buds. Large and medium sized bolls, on the other hand, are very seldom shed and will support a larva during its complete development.

First instar larvae tend to penetrate buds more frequently than bolls. This is to be expected as eggs are generally laid on the outer part of the cotton plant and will be nearer buds than bolls. Counts made during one of the insecticidal experiments showed that 52 buds to 11 bolls were infested with first instar larvae. Bolls are not penetrated nearly as quickly as buds by first instar larvae. The larvae tend to remain exposed for a longer period and also tend to tunnel in the outer layers of plant tissue.

The general rule seems to be that first instar larvae attack buds first of all and then for the rest of their development confine their attentions to bolls. During a heavy infestation, however, even 5th instar larvae have been found in buds which they can hollow-out overnight.

Parasites and Predators.

Two hymenopterous parasites and one tachinid were obtained from *Diparopsis* larvae. One of the former was relatively abundant and is probably of importance.

Neuropterous larvae were plentiful on the cotton plants in January and February. They have been known to attack 1st. instar larvae in the laboratory.

Importance of Ratoon Cotton.

The cotton sticks are cut or pulled out at the end of the season and, since the old cotton land is not flooded again the next season, the growth of ratoons or seedlings from debris depends on rainfall. If the rains begin in July as is usual the ratoon cotton will sprout and be in a condition suitable for the breeding of *Diparopsis* long before the cotton crop is sufficiently advanced. Since *Diparopsis* feeds only on cotton it is probable that the presence of ratoons is of great importance in building up the initial population and in determining the severity of the infestation on the crop. In 1951 rains were poor and late and ratoon growth was slight and this may well have been an important cause of the lightness of the attack.

EARIAS SP.

Fewer observations were made on this bollworm since it is regarded as being of less importance than *Diparopsis*.

1st. instar larvae of *Earias* tend to wander more than *Diparopsis* and often leave one bud for another. Like *Diparopsis* they reject the outer plant tissues when penetrating a fruiting point and are often contained in shed buds.

The only parasite found was one hymenopteron.

Importance of Abutilon.

Unlike *Diparopsis* a resting stage is not known to occur with *Earias*. It has however alternate host plants on which it must survive the dead season for cotton. The most important of these in the Gash

would appear to be *Abutilon* which is widespread. This plant occurs along the banks of the canals and in the cotton fields quite often in localised areas. During the summer it is in a pretty dried up condition, but sprouts again when the rains begin or when the flood affects canal banks and watered fields.

In 1951 the late and poor rains coupled with a late flood delayed the growth of *Abutilon* both in fields and along canal banks and it did not start to grow until September, by the end of which there was vigorous growth and plenty of fruiting points. It began to dry up at the end of November except on the watered fields, where growth continued until May.

Repeated examinations in August failed to reveal any *Earias* on *Abutilon* and it was not till 3 September that larvae were found in the fruits — on a plant that had been more advanced than the rest and was then beginning to dry up. After the middle of September the infestation increased but nevertheless the majority of plants were not attacked; at the end of September the infestation of fruits in one area was 1.5 per cent. By the beginning of October vacated fruits were found and it was concluded that the larvae had pupated and this was confirmed by observations on caged larvae. As the pupal period at the time was 7 — 9 days, moths were expected to be on the wing by the second week in October but they were not actually observed in the cotton fields till the third week.

The above observations were from *Abutilon* away from the cotton fields. In the cotton fields *Abutilon* was rarely infested until April. During April and May 1000 fruits were examined every fortnight and the infestation was as follows.

21	April	0.8 per cent
7	May	2.2
22	May	1.3

A movement from the drying up cotton might well have been expected but this did not place or only on a very small scale. The inference is that most of the population of *Earias* must have perished at the end of the season.

It appears therefore that *Earias* must carry over the dead season on *Abutilon* but at a very low level of population. Other host plants will be examined.

TRIALS WITH INSECTICIDES.

LARGE REPLICATED EXPERIMENT WITH DDT.

This experiment covered 5 feddans. Treatments were as follows.

(0.1 per cent DDT emulsion at 1 lb. DDT per feddan).

1. 10 weekly sprayings from 1 November till 3 January
2. 6 weekly sprayings from 1 November till 6 December
3. 3 weekly sprayings from 1 November till 15 November
4. 1 spraying on 1 November.
- 5-9. Control. Unsprayed.

Plots were 20 x 20 m., replicated in 5 Blocks and randomised within Blocks.

Later Treatments 1. and 2. were given 3 more sprayings between 11 February and 9 March, and one of the control lots 4 sprayings between 26 January and 9 March. This was to see if other pests, thought to be causing damage, would be controlled.

Large numbers of observations were carried out on the incidence of eggs, larvae and shedding in the various treatments.

The experiment did not show any control of bollworms and there were no significant differences between treatment yields of cotton.

Jassids, whitefly and flea beetle caused damage in November; the sprayed plots were free from this damage. Flea beetle increased later and this was the main reason for the late sprayings given to some treatments.

The sprayed plots looked much healthier than the controls and the lack of significant difference in the yields may well be due to the experimental error under Gash conditions. Treatment 1. gave 110 lbs. of seed cotton as against 84 lbs. for the controls.

SMALL SCALE EXPERIMENTS.

Most of the insecticidal work this season has been on a small scale, using single plants. The low population of both *Diparopsis* and *Earias* in the field has necessitated the artificial infestation of plants either by means of eggs or 1st instar larvae. *Diparopsis* was the test subject most commonly used.

The following chemicals were tested as to their ovicidal and larvicidal properties :—

Chemical MT	Chemical NC9
" JT	" NC12
" CR479	" NC13
" CR686	" NC18
" MB	" NC19
" NC7	" DDT MT. (See large scale experiment for DDT).

The toxicity of CR686 to adult *Diparopsis* was also investigated.

Technique used in ovicidal experiments.

The ovicidal experiments, unless otherwise stated, were carried out using the Immersion Technique. Batches of eggs contained on muslin were dipped into the chemical solutions, until wetted, after which they were taken out and allowed to dry. Both eggs about to hatch and newly laid were used in most of the experiments.

Technique used in larvicidal experiments.

As cotton plants cannot be grown satisfactorily in the laboratory, all the larvicidal experiments took place in the field. The technique consisted of making a series of infestations before and after treatment over a period of one, two or three weeks. The plants were infested by means of eggs or 1st. instar larvae, eggs being preferable. The eggs which were contained on muslin, were cut out singly and transferred to the plants the day before they were due to hatch.

Sites of infestation were as follows :—

- | | |
|--|--|
| (1) Between bract and boll bud. | Contact effects reduced. |
| (2) On outside of bract | } emerging larvae
exposed to contact effects. |
| (3) On the terminal leaves of sympodia | |

Summary of ovicidal results.

Table 28 gives a summary of the ovicidal results.

It will be noted that with the chemicals MT, JT and NC 13 there is a considerable decrease in toxicity as the day of treatment approaches the day of oviposition. With chemical MB there is no such decrease in toxicity. The explanation for this is that none of these chemicals are strictly ovicidal, the larvae being killed by contact on emergence from the egg as evidenced by the larvae fully maturing and the cracked egg shells, *i.e.* the degree of mortality to eggs of varying ages depends upon the persistency of the chemical. The stage of incubation at which the chemical is applied, unless it is persistent, is, therefore, of great importance in considering control measures.

Of all the chemicals investigated, MT possesses strongest ovicidal properties.

Table 28.
Summary of Ovicidal Results.

Chemical	% Concentration	No. days after treatment eggs due to hatch.	% Mortality	Remarks.
MT	0.001	1	100	All eggs matured fully
	0.0005	1	91.7	" " "
	0.0001	1	0	" " "
	0.01	5	100	" " "
	0.005	5	91	" " "
	0.001	5	59	" " "
JT	0.025	2	100	" " "
	0.0125	2	90	" " "
	0.1	5	96	" " "
	0.05	5	97	" " "
CR479	0.3	1	0	
	0.01	1	100	
	0.005	1	58	
CR696	0.01	4	100	
	0.005	4	58	
MB	0.25	1	100	All eggs matured
	0.1	1	98	" " "
	0.05	1	88	" " "
	0.1	4	87.5	" " "
	0.05	4	60.9	" " "
	0.25	5	100	" " "
	0.125	5	97.2	" " "
NC7	0.3	1	100	
	0.1	1	57.1	
	0.3	2	100	
	0.01	2	0	
	0.3	3	100	
	0.1	3	47.6	
NC9	0.5	1	92.9	
	0.1	1	83.3	
	0.01	1	0	
NC12	0.5	1	100	
	0.1	1	87.5	
	0.01	1	0	
NC13	0.01	—	100	Earias eggs.
	0.025	1	64.7	All eggs matured
	0.025	3	0	" " "
NC18	—	—	—	
NC19	0.5	3	100	
	0.1	3	20	

N.B. Unless stated eggs of *Diparopsis* were used.

Systemic-Ovicidal properties of CR686.

From results of experiments carried out against jassids in the Sudan it is thought that CR686 is able to kill eggs of this insect systemically *i.e.* the chemical is translocated through the plant tissues and absorbed by the eggs. An experiment to determine whether eggs of *Diparopsis* could be killed in a like manner was carried out by painting solution of CR686 on the surface of leaves bearing eggs. Although solutions containing 0.5 per cent and 0.125 per cent CR686 were used, no control of eggs was obtained.

Larvicidal Experiments.

Table 29 summarises the experiments carried out. Concentrations and test subject used are given.

Table 29.
Summary of Larvicidal Experiments.

Chemical	Type of Experiment.	Test Subject	% concentration
MT.	Single plants artificially infested	1st instar Diparopsis	0.1, 0.05,
MT.	Absorption of chemical through stem.	" " "	0.1
MT.	Absorption of chemical through leaves.	" " "	0.1
MT. + DDT.	Large scale experiment using natural infestation.	All stages of Diparopsis and Earias.	0.2% MT + 0.1% 0.1% MT + 0.1% 0.1% MT only.
JT.	Single plants artificially infested	1st instar Diparopsis	0.1, 0.05, 0.01
CR479	" " " "	" " "	0.5, 0.3, 0.5
CR686	Single plants artificially infested Designed to test systemic action only.	" " "	0.5, 0.1
CR686	Large scale experiment using natural infestation.	All stages of Diparopsis and Earias.	0.5, 0.1
MB.	Single plants artificially infested	1st instar Diparopsis	0.1, 0.05, 0.01
MB.	Large scale experiment, using natural infestation.	All stages of Diparopsis and Earias.	0.5, 0.25
NC7	Single plants artificially infested	1st instar Diparopsis	0.3, 0.1, 0.01
NC9	" " " "	" " "	0.5, 0.1, 0.01
NC12	" " " "	" " "	0.5, 0.1, 0.01
NC13	" " " "	" " "	1.0, 0.5, 0.05
NC18	Single plants artificially infested Designed to test systemic action only.	" " "	0.5, 0.1,
NC18	Single plants artificially infested. Designed to test systemic action only.	" " "	0.5, 0.1
NC19	Single plants artificially infested	" " "	0.5, 0.1, 0.01

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Chemical MT.

(a) Single plants artificially infested.

(i) MT at concentrations of 0.1 per cent and 0.05 per cent gives a partial control of 1st instar larvae of *Diparopsis* which have penetrated buds and bolls before treatment.

(ii) MT at a concentration of 0.1 per cent gives a complete control of 1st instar larvae for at least three days after treatment. At a concentration of 0.05 per cent there is a complete control for one day after treatment; two days after, the control is partial or complete depending upon egg placement, and three days after, partial control only. There is only a control for one day after treatment with a concentration of 0.01 per cent.

(iii) At all concentrations there is no kill after six days.

(iv) The experiment gives no evidence for any control due to systemic action. That larvae already contained in a bud or boll are killed can be explained by the fact that they often wander to the outside, or that they may not be completely enclosed within the bud or boll.

(b) Absorption of chemical through stem.

There is evidence to show that a 0.1 per cent solution of MT, taken up through the stem of a sympodium, is lethal to larvae feeding on fruiting points contained on the sympodium. In all cases the larvae had penetrated the fruiting points before dying.

Although this method of testing an insecticide gives positive results, it suffers from serious disadvantages, the most important being the impossibility of keeping cotton plant cuttings alive for more than a day or two. This prevents any determination of persistency being carried out, and in addition, as soon as the plant is cut and placed in water its internal physiology will have been altered due to wilting.

(c) Absorption of chemical through leaves.

There is no evidence to suppose that a 0.1 per cent solution of MT is absorbed through the leaf and translocated to the bud of a cut sympodia in sufficient quantity to be lethal to young larvae of *Diparopsis*.

The results, however, cannot be regarded as conclusive as the cotton plants quickly begin to wilt even if placed in water and this may seriously affect any absorption and translocation of the chemical solution.

(d) Large scale experiment using natural infestation.

Diparopsis.

(i) Plots of large cotton which are treated with 0.2 per cent MT + 0.1 per cent DDT at a dosage rate of 80 galls/feddan, show a complete absence of 1st instar larvae of *Diparopsis* two days after treatment. Six days after treatment, 1st instar larvae begin to infest the plants. Eleven days after treatment no control of 1st instar larvae can be detected.

There is, therefore, evidence to show that large cotton treated with 0.2 per cent MT + 0.1 per cent DDT at a dosage rate of 80 galls/feddin effectively controls 1st instar larvae of *Diparopsis* for a period of something less than six days.

(ii) Plots of large cotton which are treated with 0.1 per cent MT + 0.1 per cent DDT and 0.1 per cent MT only, do not show a complete reduction of 1st instar larvae of *Diparopsis*. It is possible that a partial control is obtained, but such a control would probably be ineffective in reducing the population to any great extent.

(iii) With all treatments there is no observable reduction of later instars of *Diparopsis*.

(iv) There is no evidence for any control of eggs. This is probably due to the impossibility of obtaining a satisfactory spray cover on very large cotton.

(v) Later instar larvae of *Diparopsis* are killed when caged over plant material treated with 0.2 per cent MT + 0.1 per cent DDT two days after treatment.

Earias.

The number of *Earias* larvae were too few for any results to be obtained.

Chemical NC13 (Single plants artificially infested).

(i) NC13 at a concentration of 1.0 per cent gives a partial control of 1st instar larvae of *Diparopsis* which have penetrated bolls two days, and buds one day before treatment. At concentrations of 0.5 per cent and 0.05 per cent NC13, there is no control of larvae that have entered bolls two days before treatment, but there is a partial control of larvae that have entered buds one day before treatment.

(ii) NC13 at a concentration of 1.0 per cent gives a complete control of 1st instar larvae of *Diparopsis* for at least two days after treatment regardless of egg placement. A partial control occurs at concentrations of 0.5 per cent and 0.05 per cent NC13 when eggs are placed on the inside of bracts and a complete control when eggs are placed on the outside of bracts or on the sympodial leaves.

(iii) NC13 at concentrations of 1 per cent and 0.5 per cent exhibits strong ovicidal properties when eggs are placed on the outside of bracts or on sympodial leaves after the spray has dried.

(iv) No control of larvae at any concentration occurs six days after treatment.

(v) There is no evidence to show that NC13 kills 1st instar larvae of *Diparopsis* systemically.

Chemicals JT, CR479, CR686, MB, NC7, NC9, NC12, NC18 and NC19.

There is no evidence to suggest that these chemicals are effective as larvicides against 1st instar larvae of *Diparopsis*.

Toxicity of CR686 to adults of Diparopsis.

CR686 at concentrations of 0.1 per cent, 0.05 per cent and 0.01 per cent is toxic to adults of *Diparopsis* when they are exposed to a fresh dry insecticidal film contained on muslin. Persistency of CR686 at a concentration of 0.1 per cent is at least four days.

SOIL RESEARCH SECTION

by *T. N. Jewitt.*

1. Introduction.

This report gives an account of the work of the whole staff of the section. The senior staff is as follows :—

T. N. Jewitt.

T. A. Jones.

K. R. Middleton.

J. K. Henderson.

Mohd. Abdel A'al.

The work of the section has continued on the usual lines. A full soil survey staff enabled a large area to be surveyed in Northern Province. A new laboratory came into service and will enable the laboratory work to keep pace with the expanded soil survey. A considerable number of soil survey samples have been taken by workers employed by Sir Alexander Gibb and Partners. Apart from soil survey work the senior staff have spent less time than usual away from Medani. Research on Gezira problems has continued mainly on organic nitrogen and on crop nutrition.

2. Meteorology.

The usual supervision of the seven Gezira stations has been continued. Results are given on p. 12.

3. Soil Survey and Reconnaissance.

A. Blue Nile Province (Northern Fung).

Three groups of holes were dug across the area between the Blue Nile and the White Nile and lying between the Sennar-Kosti railway line and lat. 12° 50' N.

Considering these separately the sodium values of the western group of holes are distributed in the following way. (The sodium value is the exchangeable plus soluble sodium as mg. equivalents per 100 g. of clay.)

Table 1.

Sodium Value Range.	Number of Holes.
0- 5	2
6-10	42
11-15	48
16-20	8
21-25	5
26-30	5
31-35	2
over 35	15

The holes with values larger than 35 are territorially grouped together. Closer inspection of the range 6-15 shows a wide scatter and no grouping round a particular value. In most areas of the clay plains where this method has been employed the sodium values are grouped round a most frequent value with at least approximation to a normal distribution.

The central group of holes has the distribution shown below :—

Table 2.

Na Value	Number of Holes.
5	1
6	1
7	6
8	7
9	7
10	16
11	25
12	30
13	8
14	10
15	2
16	1

This area is remote from either of the rivers; the distribution of sodium values is similar to that given for one group of holes in the Eastern Butana survey last year which was also remote from the river.

The third group of holes in the east of the Northern Fung gave a distribution of sodium values shown below.

Table 3.

Na Value	Number of Holes.
0- 5	6
6-10	9
11-15	32
16-20	51
21-25	33
26-30	30
31-35	7
35-40	6
over 40	0

This is the usual sort of distribution for these clays and similar to that for the Busata Area on the opposite side of the Blue Nile. Actually there is a local concentration of holes with high sodium values and, if these were cut out, the rest of the area would show a very favourable distribution. The area is heavily wooded.

There is considerable evidence in this work that sodium values are not decisively influenced by present rainfall, but are the results of the original manner of formation of the soil.

B. Northern Province.

A large survey along the whole length of the Nile from Khartoum to Abu Hamad has been carried out. This stretch of the river is about 350 miles long. Every 4 km. a cross section has been level-surveyed and on the cross sections holes have been dug every km. between the river bank and a point 15 m. above low river level. It is hoped that by this means we have sampled substantially at random and that we shall obtain a valid estimate of the total area worth irrigating.

C. Khartoum Province (Gummuiya).

This is a riverain area intended for immediate development. It proved to be very variable both in texture and salt content. Some holes had sodium values of over 50 and in some cases there was more than 1 per cent soluble salt in the top three feet. A few holes were shallow on sandstone.

4. Soil Nitrates Plots 10-15

The distribution of nitrates in the upper two feet of soil was measured once a month throughout the year. In this year of very low presowing rains (49 mm.) the surface nitrates during the early growing season were high, in accord with expectation. Table 4 gives the detailed results for successive 6 inch steps, in p.p.m. nitrate nitrogen on oven-dry soil.

Table 4.
Nitrates p.p.m. Three Course Rotation experiment.
(6 inch steps)

ROTATION	16.5.51 Step				18.6.51 Step				17.7.51 Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1	7½	4	4	3	7	6½	5	4	7	4½	6	3½
2	6	4	2½	1½	7	7	5	2	8	5	4	2
3	1	1	1	1	1	1	1	1	1	1	1	1
4	19	11	10	4	22	21	15½	8½	13	14	13½	10
5	2½	2	2	1½	2	3	2½	2	2½	4	4	2½
	15—18.8.51 Step				19.9.51 Step				15.10.51 Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1	11	2½	4	5½	4	3	2½	3	6	2	2	2
2	7½	2½	3½	5	5	3	3	3½	4½	2½	2	3½
3	3	1	1	1	6½	3	2	2	3	1½	1	1
4	28	9½	15	10	17½	9	9	11½	10	3	2½	7
5	11½	4½	7	4½	14½	6	5½	7	10½	4½	5	4½
	27.11.51 Step				26.12.51 Step				9.1.52 Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1	6	1½	1½	1½	4½	2	1	1	10½	2	1½	1½
2	3½	2	1½	1½	7½	1½	1½	1½	9	2	1½	1
3	1½	1½	1½	2½	5½	1½	1½	1	8	1½	1½	1½
4	9½	2	2½	2	9	1	1½	2	18½	2	2	2
5	5	1½	1½	1	4	1½	1	1	6	2	1	1½
	17.2.52 Step				17.3.52 Step							
	1	2	3	4	1	2	3	4	1	2	3	4
1	3½	1	1	1	4½	1	1	1				
2	2	1½	1½	1½	8	1	1	1½				
3	1½	1½	1	1	2½	1	1	2				
4	15½	2	1½	2½	21½	3½	1½	1½				
5	5½	1½	1	1	10	1½	1	2				

The sampling was done on the cotton plots of the experiment as usual. This is the sixth year of this sampling which is done in considerable detail (8 samples per treatment).

The cotton plants growing on the sampled plots are analysed at about the same date each year. These results are given in the section below.

5. Analysis of Cotton Leaves.

This investigation was carried out in collaboration with the Plant Physiology Section, who did the sampling and supplied the yields.

The cotton plants of the five rotations of the Three Course Rotation experiment on Plots 10 and 11 were sampled on 27.9.51. The following table gives the oven-dry weight of the leaf samples (20 plants) and the percentages of N, P₂O₅, K₂O and CaO in each sample on an O.D. basis.

Table 5.

Rotation	Sub-plot	Wt. of sample	% N	% K ₂ O	% P ₂ O ₅	% CaO	Final Yield.
CFF	4	23.5	4.26	3.51	0.93	6.72	3.66
	9	27.3	4.17	3.31	0.98	7.31	4.24
	11	25.2	4.39	2.88	0.94	7.07	2.77
	18	24.5	4.36	2.80	0.95	6.85	3.88
	Mean	25.1	4.29	3.12	0.95	6.99	3.64
CDF	1	29.2	4.16	3.52	0.92	6.44	2.87
	10	23.3	3.93	3.54	1.05	6.51	3.19
	15	32.6	4.14	3.08	0.92	6.44	3.44
	16	25.0	3.79	2.81	0.91	6.65	3.46
	Mean	27.5	4.00	3.24	0.94	6.51	3.24
CDD	2	21.7	3.54	3.39	1.29	5.74	1.66
	7	16.4	3.76	3.39	1.18	6.02	2.32
	13	24.8	3.34	2.74	0.94	5.38	1.83
	20	21.6	3.19	3.10	1.04	5.18	2.24
	Mean	21.1	3.46	3.15	1.11	5.60	2.01
CLF	3	34.6	4.26	3.06	0.70	6.58	4.53
	6	32.3	4.08	3.56	0.83	6.37	4.90
	14	31.0	3.95	2.64	0.66	5.78	4.46
	19	36.8	4.30	2.75	0.85	6.58	5.46
	Mean	33.7	4.12	3.00	0.76	6.33	4.84
CDL	5	36.5	4.40	3.42	0.82	7.00	4.16
	8	30.8	4.28	3.45	0.83	6.23	4.80
	12	32.5	4.19	3.01	0.87	6.71	3.43
	17	34.0	4.24	3.58	0.80	6.12	4.10
	Mean	33.4	4.28	3.36	0.83	6.51	4.12

This is the third year in which the plots have been sampled at about the same date. The presowing rainfall for the three years 1949/50, 50/51 and 51/52 have been 69, 180 and 49 mm. respectively. Table 6 gives the mean weights of the samples and the mean of the uptakes from the 5 rotations for the three years.

Table 6.
Content of nutrients, (g. per 100 plants) in leaves
at the end of September.

Year				N.	K ₂ O	P ₂ O ₅	CaO	Yield of Cotton (r.p.f.)
1949/50	...	...	...	2.7	2.5	0.7	4.4	3.6
1950/51	...	...	...	2.0	2.0	0.6	3.3	5.7
1951/52	...	...	...	5.4	4.3	1.2	8.6	3.6

In 1951/52 the cotton was sprayed against jassids for the first time. It is presumed that this increased the yield and that otherwise the yields would have been in the order of the presowing rainfalls.

Table 6 shows that the uptake of nutrients by the young leaves has been inversely related to the final yields. This is in the main true also of the percentage nutrients and the final yields.

So far as nitrogen is concerned the uptake by the young plants is in fair relationship with the soil nitrates as measured during August and September. Table 7 gives these measurements as means of the measurements for all the rotations.

Table 7.
Nitrate nitrogen content (p.p.m.) in August and September.

Date					Depth in inches			
					0—6	6—12	12—18	18—24
12.8.49	...	...	...	...	10.5	7	8.5	14
15.8.50	...	...	...	...	4.5	2.5	3	8
17.8.51	...	...	...	...	15	4	6	5
11.9.49	...	...	...	...	9	2	2	4
16.9.50	...	...	...	...	3	2	2	2
19.9.51	...	...	...	...	9.5	5	4.5	5.5

It has long been thought possible that in good years the cotton plant absorbs nutrients particularly efficiently; this work seems to show that this is not the case during the early stages of growth.

6. Deep Nitrates.

It has long been known that Gezira soil has a well marked zone of accumulation of nitrate at depth. At the end of the season in April deep bores were taken on plots 10 and 11 and the nitrate measured in the fresh samples to six feet. Table 8 gives the mean figures for each rotation in oven dry soil.

Table 8.
Nitrate-nitrogen (p.p.m.) in Plots 10 and 11 April 1952
Depth in feet.

Rotation	Depth in feet.					
	0—1	1—2	2—3	3—4	4—5	5—6
CFF.	2	1	1	5	20	30
CDF.	2	1	1	1	7	21
CDD.	1	1	1	1	5	14
CLF.	2	1	1	7	22	40
CDL.	2	1	1	3	18	33

The work showed the extreme difficulty of obtaining valid figures for deep nitrates. The results above are the means of 8 determinations and the variability is enormous. CDL for example included the following two contrasted distributions.

- (a) 1 1 1 0 1 3
(b) 2 1 1 14 42 54

The figures are for descending samples.

Table 9 gives strictly comparable data from a determination made on the same plots in June 1946, again after a cotton crop.

Table 9.
Nitrate nitrogen (p.p.m.) in Plots 10 and 11. June 1946

Rotation	Depth in feet.					
	0—1	1—2	2—3	3—4	4—5	5—6
CFF.	4	2	1	4	16	21
CDF.	2	1	1	2	5	16
CDD.	2	1	1	1	5	16
CLF.	2	2	1	1	5	18
CDL.	2	1	1	6	19	20

The general form of the distribution is similar, but the figures for the deep samples are generally lower than in 1952. It is clear that study of the distribution of nitrate in depth is likely to be very difficult.

Deep nitrates were measured in the continuous cotton plot on 24-28.5.51 and in only 2 out of 20 bores were nitrate accumulations found at 6 feet. The moisture content of the soil of this plot was much higher than for other plots immediately after a cotton crop.

7. Simulated Rainfall Experiment.

Soil investigations in this experiment were confined to the untreated plot and the sprayed plot. The furrow-irrigated plot was not investigated.

On 9 — 11 June 1951 the plots were sampled, eight 6 foot holes being bored in each. The mean soluble salts were measured conductimetrically and nitrates and moisture were measured. Results are given in Table 10.

Table 10.
Percentage Soluble Salts (Air dry)

			Depth in feet.					
			1	2	3	4	5	6
Untreated	...	...	0.067	0.100	0.246	0.577	0.519	0.600
Sprayed	...	...	0.075	0.115	0.181	0.522	0.521	0.788

Nitrate-nitrogen p.p.m. (oven dry)

			Depth in Feet.					
			1	2	3	4	5	6
Untreated	...	...	4	3	2	2	7	19
Sprayed	...	...	5	4	2	3	16	31

Moisture Percent (oven dry)

			Depth in Feet.					
			1	2	3	4	5	6
Untreated	...	...	8	20	22	23	23	21
Sprayed	...	...	11	20	22	23	23	20

The exchangeable sodium was measured in the upper three feet of soil. The untreated and sprayed plots had 10 and 11 mg.e. per 100 g. of soil respectively.

The only important difference found in this preliminary examination was in the nitrates in the 6th. foot. Nitrates in the upper soil were measured a number of times and showed no striking differences. The means of 4 determinations between 4.8 and 6.9.51 were as follows.

Nitrate Nitrogen (p.p.m.)

			Depth in inches			
			0—6	6—12	12—18	18—24
Untreated	...	...	5½	4½	4	4½
Sprayed	...	...	3	2½	2	3

From 6.9.51 until 10.1.52 the nitrates in the top 2 feet of soil were closely similar.

On 16.1.52 deep bores were made and showed the following distributions of nitrate.

Nitrate-Nitrogen (p.p.m.)

			Depth in Feet.					
			1	2	3	4	5	6
Untreated	...	...	2	1½	1	1	3½	10½
Sprayed	...	...	1	1	1	1	4½	19

Spraying started on 1.7.52 and finished by 4.8.51. A moisture sampling on 19 and 21.7.51 give the results below.

Moisture Percent (over-dry)

			Depth in Feet.					
			1	2	3	4	5	6
Untreated	...	...	10	20	24	25	25	23
Treated	...	...	34	26	23	23	23	23

It is surprising that the wetting of the upper soil did not cause any measurable nitrification. If this effect could be confirmed and compared with the effect of an equivalent amount of rain it would be of considerable interest.

8. Salt Distribution.

Plot 75.

In 1927 Greene examined the distribution of salts in this plot to a depth of six feet. The distribution was re-examined this year. Greene's examination was by six inch steps, and ours by one foot steps. Table 11 gives the results as water soluble salts measured conductimetrically.

Table 11.
Water soluble salt per cent in Plot 75.
April 1927

Salts % ...	Depth in inches.						
	0—6	6—12	12—18	18—24	24—30	34—36	
	0.12	0.11	0.11	0.11	0.13	0.21	
		36—42	42—48	48—54	54—60	60—66	66—72
		0.43	0.57	0.52	0.41	0.49	0.69

Average to 6 feet 0.32%

April 1952

Salts % ...	Depth in feet.					
	0—1	1—2	2—3	3—4	4—5	5—6
	0.09	0.13	0.38	0.48	0.58	0.73

Average to 6 feet 0.40 %

The comparison between absolute values requires further consideration as if the comparison is valid the change is important. It will be noticed that in the averages the minimum found by Greene at 54-60 inches does not appear in the later figures, and this seems a real difference. Both studies used 11 bores: in nearly all Greene's the minimum is well marked but in six of ours there is no trace of it.

Plots 10 and 11.

Similar measurements of salt distribution have been done on these two plots of the Three Course Rotations and Table 12 gives the mean results for the 5 rotations. Eight holes were bored in each treatment.

Table 12.
Water soluble salts per cent. Plots 10 — 11.

Rotation	Depth in feet.					
	0—1	1—2	2—3	3—4	4—5	6—6
CFF.	0.08	.12	.32	.59	.65	.70
CDF.	0.08	.11	.33	.60	.69	.72
CDD.	0.09	.12	.27	.49	.65	.68
CLF.	0.09	.13	.46	.61	.70	.73
CDL	0.09	.11	.38	.59	.58	.62

The difference between the rotations are small and probably not significant, though there is a general tendency for the rotations CDD and CDL which are irrigated every year to have the lowest salt contents. The averages show no minimum, and neither do many of the separate samplings. It is true that sampling every foot is liable to miss minima; however on the whole these data seem to support the idea that the salt minimum which existed 25 years ago is not now present in irrigated Gezira soil.

9. The Distribution of Phosphate in Depth in Tropical Sudan Soils.

This study was initiated in connection with the practice of bush fallowing, which is commonly employed in the southern Sudan to rejuvenate exhausted land. The process is often considered to involve a removal by deep rooted plants, having themselves a very low nutrient demand, of various plant nutrients including phosphate. These are subsequently concentrated at the surface in an available form amongst plant debris. The process takes from 10 to 15 years and it is thought that, during such a period of tropical weathering, forms of phosphate initially unavailable, may become available slowly to the roots of the "fallowing" plant. For this reason a powerful extracting reagent has been used in the estimations and the results may be considered to be effectively total phosphate. Only refractory, unweathered minerals would be excluded. The method of extraction employed has been the digestion of soil with hot 50 per cent nitric acid, followed finally by colorimetric determination of phosphate.

Two areas in the southern Sudan have been included in this investigation. One in the Yirrol Toich area of Bahr El Ghazal Province, the other at the Yambio Experimental Farm, Equatoria Province.

SITES OF THE HOLES EXAMINED.

(a) *Yirrol* (Table 13).

Hole K is located in very infertile "ironstone" country. The soil results from "lateritic" weathering and is heavily leached of bases and silica. Residual sesquioxides would be expected to render phosphate unavailable to plants.

Holes E. & I. These represent soil derived from similar parent material to K. They are sited lower down a drainage slope from K and are somewhat less leached, more clayey and less stony.

Holes 1, 3, 6 & 9. These are toich soils situated on the alluvial plain of the river Lau. Seasonally flooded to a depth of several feet during the rains they out completely at the surface during the dry season. Considerably higher phosphate values than for the lateritic types are recorded. Available (Truog) figures for hole 9 are given below the total figures being shown in brackets for comparison.

Yirrol. Hole 9. available P_2O_5 mg per cent.

Foot	1	2	3	4	5	6
	5 (63)	3 (57)	3 (24)	7 (35)	4 (18)	4 (76)

(b) *Yambio* (Table 14).

All these holes represent soils, which are lateritic in nature but not such extreme types, as those at Yirrol. Hole I is abnormal, being located next to a lump of decomposing norite rock. Some of the holes have been investigated to considerable depth and usually display a decrease in phosphate with depth. There seems little evidence to assume any phosphate accumulations which may be tapped by deep-rooted plants.

Conclusions.

The average value for all lateritic samples is 22 mg per cent P_2O_5 and the average in the first foot of soil is 32 mg per cent. Corresponding figures for the toich soils are 44 and 65 mg per cent respectively.

Yambio Hole I has not been included in these calculations and it appears from it that soil in the vicinity of weathering basic rock may contain considerably more phosphate.

It should be noted that all these figures are very low compared with those of fertile soils; for example in the Sudan Gezira a figure of about 230 mg. per cent total phosphate has been obtained for the first foot of soil. Of this about 30 mg. per cent is available according to the Truog method. Ingle quotes the following figures for P_2O_5 by a comparable method:—

Tropical Red clay soil	80 mg. per cent
Tropical Red sandy soil	10 mg. per cent
Tropical Red loamy soil	40 mg. per cent
100 Soils of Dorset	300 mg. per cent

Distribution of P_2O_5 in Depth in Tropical (Sudan) Soils

Table 13 Yirrol mg per cent P_2O_5

Hole Nos.			Depth in feet						Average
			1	2	3	4	5	6	
K	...	...	41	20	12	11	2	4	15
E	...	...	16	7	17	6	12	8	11
I	...	...	20	12	7	7	13	—	12
1	...	...	43	35	26	16	19	16	28
3	...	...	75	65	79	59	4	—	56
6	...	...	78	69	80	42	44	—	59
9	...	...	63	57	24	28	18	26	38

DISTRIBUTION OF TOTAL P_2O_5 IN DEPTH IN TROPICAL SUDAN SOILS.

TABLE 14. YAMBIO EXPERIMENTAL FARM MG % P_2O_5 .

Hole 1	...	...	Depth ft. P ₂ O ₅	(0—1) 13	(2—5) 1	(6—8) 115	(9—10) 89					Average 54			
Hole 2	...	...	Depth ft. P ₂ O ₅	(0—1) 37	(1—2) 78	(3—6) 74	(7—10) 1					48			
Hole 13	...	...	Depth ft. P ₂ O ₅	(0—1) 49	(1—2) 20	(2—3) 1	(8—11) 44	(12—14) 43	(15—17) 15	(18—20) 11		26			
Hole 24	...	...	Depth ft. P ₂ O ₅	(0—1) 35	(1—2) 31	(2—3) 16	(3—4) 18	(4—5) 16	(7—9) 1	(10—12) 2	(13—15) 1	15			
Hole 25	...	...	Depth ft. P ₂ O ₅	(0—1) 35	(1—2) 30	(2—3) 10	(3—4) 10	(4—5) 24	(5—6) 19	(7—11) 13	(12—14) 22	(15—18) 22	(19—21) 29	(22—25) 44	24

YAMBIO EXPERIMENTAL FARM

by *P. de Schlippe and K.R.M. Anthony*

Annual Experiments. Cotton.

COTTON VARIETY TRIAL.

At present variety BAR. SP84 is grown throughout the area. The two previous years have indicated that BAR. 11/5, the new blackarm resistant strain derived from XA129 (formerly grown in Equatoria), is superior to SP84 which was originally bred for the Nuba Mountains. BAR. 11/5 is being bulked now to replace SP84 in the whole area.

Layout: Six varieties were compared in a randomised block experiment with seven replicates. They were:

1. BAR. 12/3 (Uganda BP52 homozygous for B_2).
2. BAR. 7/8 (Uganda SP84 homozygous for B_2 and B_3).
3. BAR. SP84.
4. Stoneville 5 (strain of an imported American variety purified at Bambesa, at present grown commercially in the cotton belt of the northern Congo).
5. S47 (a recent introduction from Uganda).
6. BAR. 11/5

Variety BAR. 13/1 was sown as belt.

Plots were 30 x 4.5 m., cotton was sown on June 6th., spaced 90 x 30 cms. The experiment was on virgin, rather rich, fire preserved grass-bush land.

Yields. Yields of all varieties were low, compared with the previous two seasons, averaging 498 Kg/ha (465 r.p.f.). This season, varieties BAR. 12/3, S47 and Stoneville 5 all averaged greater yields than BAR. 11/5. Plot variability was however high, and differences were not statistically significant. (Table 1).

Table 1.
Cotton Variety Trial.
Yields as percentage of General Average Yield
of Seed Cotton for Three Years.

Variety	1949/50	1950/51	1951/52
BAR. 12/3	97.6	102.8	109.2
BAR. 7/8	113.6	103.9	92.6
BAR. SP 84	—	—	93.8
Stoneville 5	86.1	87.8	102.2
S 47	—	—	106.6
BAR. 13/1	—	93.9	—
Mu 8b	94.4	—	—
BAR. 11/5	108.0	111.9	95.6
Average Yield Kg/ha	649	635	498
Average yield r.p.f.	607	592	465
Standard error	3.8%	3.0%	6.8%
Significant difference $P = 0.05$	11.3%	8.7%	Not Significant
Coefficient of Variability	9.5%	7.4%	18.2%

Grades. Cotton was graded on the basis of ease of picking into Grades A and B as described in last year's report. A feature of the season was the low percentage of Grade A compared to the previous year. The only variety with grading comparable to last season was BAR. 12/3. Probably the lowering of grade was even worse than that shown by the figures of Table 2, as practically all of the first two pickings should have been classified as B.

Table 2.
Proportion of Grades in Cotton Variety Trial

	% Variety Average		% General Average	
	Grade A	Grade B	Grade A	Grade B
BAR. 12/3	70.2	29.8	76.7	32.5
BAR. 7/8	62.9	37.1	58.2	34.4
BAR. SP 84	63.0	37.0	59.0	34.8
Stoneville 5	60.1	39.9	61.4	40.8
S 47	65.7	34.3	70.0	36.6
BAR. 11/5	64.1	35.0	61.2	34.3

Labour requirements for picking. Labour requirements for picking per ton seed cotton were much higher than the previous season and this was probably due to bad boll opening. The method of time recording is not very precise. Roughly BAR. 12/3, S47 BAR. 11/5 were better than average and Stoneville 5, BAR. SP84 and BAR. 7/8 were poorer than average, which does not tally with last year's results.

Table 3.
Cotton Variety Trial.

Labour requirements for harvesting in labour days/ton seed cotton.
First five pickings.

Variety						Grade A	Grade B	Average A + B
BAR. 11/5	...	...	...	...	...	103	175	127
BAR. 7/8	...	...	...	...	...	120	176	141
S 47	...	...	...	...	...	96	166	120
Stoneville 5	...	...	...	...	...	108	164	130
BAR. SP 84	...	...	...	...	...	112	182	138
BAR. 12/3	...	...	...	...	...	96	176	120
Gen. average	...	...	...	...	...	106	173	129

Periodism. All varieties were slightly earlier maturing than in 1950/51. This could be explained by a peculiar season during which early growth was stimulated by much sunshine, but there was also an earlier cessation of vegetative growth, possibly correlated with bad boll opening from which all varieties suffered.

Differences between varieties were not significant, but were consistent with those observed last year, BAR. 12/3, Stoneville 5 and BAR. 11/5 being slightly quicker maturing than the rest.

SPRAYED COTTON OBSERVATION PLOT.

One 26 x 35 m. isolated plot was sprayed fortnightly with DDT wettable powder at 1 lb. DDT feddan beginning on 18.8, *i.e.* 75 days after sowing, to see if any striking results would be obtained.

It was a second shift, after sunflowers; the land had originally been average grass-bushland, but looked rather exhausted. Development was on the whole considerably poorer than any other cotton trial of the season. There was the same sequence of relatively good early growth and sudden setbacks during the fruiting period. No detailed entomological observations could be carried out. Most of the usual pests could be observed before 18.8. Some of each kind, especially aphids, were seen on the sprayed plot even during the spraying period, but direct damage seemed slight.

The yield was 828 Kg./ha, better than any other on the farm this season.

DDT SPRAYING EXPERIMENT AT AGRICULTURAL TRAINING SCHOOL.

A randomised block experiment of 24 plots was carried out by the Agricultural Training School. On 12 plots DDT was sprayed 6 times (on 1.9, 15.9, 30.9, 15.10, 30.10 and 15.11) with 0.1 per cent DDT wettable powder suspension at the rate of 100 gallons per feddan.

Small, insignificant increases in yield were obtained on the sprayed plots. Pink bollworm, which was the worst pest on this plot, seemed unaffected by the treatment.

POISON BAITING FOR STAINERS.

Rough trials in 1950 were made on the effect of treating cotton plots with a solution of sugar poisoned with BHC. The kill of stainers was promising.

This season therefore a replicated experiment was carried out using the same lay out as for the DDT spraying. The treatment had no effect on yield and unfortunately no observations were made on the amount of staining. Nevertheless the yield of 832 Kg/ha was good for this season, but the experiment was on good soil.

CONCLUSIONS FROM INSECTICIDE EXPERIMENTS.

Obviously no conclusions can be drawn from the Sprayed Observation Plot nor from the A.T.S. replicated experiments. The Observation Plot and the Stainer Poisoning Plot both gave very good yields for the season. The A.T.S. DDT spraying experiment gave only moderate yields.

In the two replicated experiments, the yields of the treated and untreated plots were so close that it is probable :

- (a) that the experimental error was small as far as soil factors are concerned.
- (b) that any effect of the treatments on insect pests was evened out by the insects moving between the treated and untreated plots.

Unfortunately it was not possible to make proper entomological observations so that hardly any information was obtained on the effectiveness of the treatments.

COTTON EARLY ASSOCIATION TRIALS WITH SOYA AND GROUNDNUTS.

Object. Some hundred miles south of Yambio, where the rainy season is longer, it is common practice to sow cotton after an early crop of groundnuts. The advantage of this practice lies not only in that one opening serves two crops, but apparently also in a better cotton crop and in a reduction of the period of the soil denudation under heavy rains. During the last two years it has been established that soya can be sown as early as the Azande sow groundnuts, and that soya ripens after 85 days as compared to the 100 days required by groundnuts. Whether this difference would suffice to balance the shorter rainy season at Yambio was a matter for experiment. Cotton had to be sown into soya and groundnuts to from an overlapping succession, or early association.

Layout. Rather rich, fire-preserved grass-bush land turning into forest was chosen. With groundnuts three sowing dates of cotton were replicated in five blocks, each of the three sowing dates of a block

being split into five cotton varieties. With soya the same layout was used, but due to shortage of seed, each block had to be sown with a different variety of soya. Groundnuts were sown on April 19th and harvested on July 30th; soya beans sown on April 20th and harvested on July 12th. with a small second harvest on July 21st.

Germination. The stand of cotton was poor soon after the harvest of the associate crops. The high percentage of voids was not due to bad germination but to the death of seedlings from competition with the associate crops during the drought in late July.

The third sowing date into soya, cotton being sown after the main harvest of the associate crop, was the only treatment which completely escaped this and therefore had a normal stand. Competition with groundnuts was more destructive than that with soya, the poorest cotton being the first sowing date with groundnuts, which looked like a complete failure. The varieties which were most affected were Stoneville 5 and S47. The greatest resistance was shown by SP84 in the case of soya and by BAR. 11/5 in the case of groundnuts.

Development. The early growth of cotton in association was very slow and this delay lasted for about a month after the harvest of the associate crops, after which rapid growth began and the plants finally became the same size as cotton sown into newly opened land. Maturation of the plants was also delayed and there was no bad boll opening.

Yields. The average yields were: 1) groundnut association — 496 kg. of seed cotton and 924 kg. of groundnuts (unshelled) per hectare (465 and 862 r.p.f.) and 2) soya association — 779 kg. of cotton seed and 619 kg. soya per hectare (727 and 578 r.p.f.). The best yields were obtained from the second sowing dates (June 15th) in both experiments. The differences were, however, not statistically significant. The season was favourable to late sowing dates. Moreover the cotton of the first sowing date suffered a great setback from its bad stand count and it is astonishing that it caught up to almost average.

COTTON ASSOCIATION TRIAL WITH GROUNDNUTS BY THE AGRICULTURAL TRAINING SCHOOL.

This was a duplicate of the above experiment. It was sown on medium degraded grass-bush land, not fire protected. This trial gave results very similar to the cotton-groundnuts association of the Y.E.F. A total yield of 669 kg/ha of seed cotton and of 994 kg/ha of groundnuts (625 and 927 r.p.f. respectively) can be considered as satisfactory. The lower yield of the intermediate sowing date (June 25th.) was the only result not consistent with those obtained at the Y.E.F. The differences in yields according to sowing dates were not significant.

COTTON DEVELOPMENT.

394 cotton diagrams were made in various experiments, but are not reproduced here.

The 1951/52 season was very unfavourable for cotton through the whole area. The number of buds, flowers and ripe bolls per plant in the Observation Plot were 30, 13.5 and 2.2 in 1951 as against 42, 20

and 5.7 in 1950. From an examination of meteorological data it seems probable that in 1951 the drier and sunnier weather in June and July was stimulating to growth, but not to bud production. A short drought accompanied by much sunshine at the end of August suddenly stopped growth as well as bud production. More shedding of buds (55 per cent in 51, but only 29 per cent in 50) might be attributed to dry and variable weather in August. More shedding of bolls (84 per cent instead of 72 per cent) coincided with the drought period at the end of August.

As already mentioned during this period bad boll opening set in, which apparently further reduced the yield except in the Association Trials.

Bud production. Total buds and productive-period buds were practically the same in the variety trial as in the Observation Plot. Differences between varieties seem to be erratic, probably due to the number of diagrams taken from each (20) being too small. The sprayed plot had a considerably higher production of buds than the Observation Plot. The reason for this is not clear and cannot be attributed entirely to spraying, which was only started 75 days after sowing. The highest bud production was observed on cotton plants growing on or next to termitaria, and on the two first sowing dates of cotton in association. With the latter, higher bud production was undoubtedly due in part to a wide spacing produced by a bad stand, but in part also to a delayed and lengthened period of bud production.

Bud shedding was highest in the Variety Trial, reducing the number of flowers to the level of the Observation Plot. Stoneville 5 had less bud shedding than any other variety and this apparently accounted for its high yield. The Sprayed Plot suffered much less from shedding of buds than the Observation, so that the number of flowers per plant (total and useful) was 50 per cent higher. This took place mainly before spraying and the reason is unknown. In the association trials there was on the whole much less bud shedding than in the Observation Plot. This was again partly due to spacing. The second and third sowing dates of the soya association which had a better stand showed more shedding. With cotton on termitaria bud shedding was slightly less than on the whole of the Observation Plot.

Boll shedding was as bad in the Variety Trial as in the Observation Plot. BAR.7/8 seemed to be less affected and this probably explains its high yield. The Sprayed Plot had again less boll shedding, so that the number of its ripe bolls reached twice the number of those of the Observation Plot. This difference took place throughout September and October and may be due to the effects of spraying. Cotton in association with soya showed for the first two sowing dates less boll shedding, but for the 3rd sowing date more than the Observation Plot. In all three graphs of cotton with soya there was a sudden increase of boll shedding during the last pentade of October, which coincided with exceptionally high humidity. In association with groundnuts the 1st sowing date was similar to the Observation Plot, whereas the 2nd and 3rd suffered from more boll shedding. This apparently reduced what promised to be a very good crop to a moderate one. It was probably due to the bolls maturing too late in the season.

Yield. The highest yield, that of the 2nd. sowing date of cotton into soya, seems to be due to a good stand, good bud production, moderate bud shedding and low boll shedding. Cotton around termitaria had a normally bad boll shedding, but due to a good bud production and slightly less bud shedding it had a good yield. On the contrary cotton on the top of the termitaria had the worst boll shedding which brought its yield down to the level of the whole Observation Plot.

On the whole the final yield seems to depend mainly on the original bud production capacity and absence of boll shedding, bud shedding being less important.

Weight per boll. The weights of seed cotton, which varied from 0.5 to 7.5 gms. from boll to boll, showed when averaged only a slight variation from 3 to 3.5 gms. for different treatments in different experiments. Even so, the slightly heavier bolls of the Variety Trial were partly so because of imperfect drying a very wet October. Considering the bad opening in all but the association trials, this absence of any differences in boll weight is puzzling. One would expect immature seeds and fibres from badly opened bolls to be lighter.

Number of bolls per plant. In view of the relative constancy of boll weight, this should be as representative of the yield of a treatment, as weights of seed cotton per plant. The yields of the different varieties did not accord with these data but this is probably because the number of diagrams per variety was insufficient. But there was a good correlation between yields and bolls per plant in most experiments, working out at 200 kg/ha per boll. An exception was the groundnut association but this can be explained by the bad stand on these plots.

Periodism. The lengthening of the period from sowing to maturity mentioned in the description of the Association Trials is analysed by the plant diagrams. These show that the delay took place entirely in the sowing to budding period, whereas the budding to flowering period is the same throughout, and the flowering to maturity period is slightly shorter in the Association Trials. Considering that this period fell mainly into December for all Association Trials and into October — November for all the other cotton; and considering that rains were very heavy in October and up to the 26th. of November and then stopped abruptly, with a corresponding increase in sunshine and vapour pressure deficit, the shortening of the bolling period would be expected to have been greater. It seems therefore likely that in the experiments picked earlier, this period has also been shortened as compared to a theoretical normal. This would be due to bad boll opening.

Annual Experiments. Crops other than Cotton.

DURA ASSOCIATION TRIALS.

Object. This was a continuation of work begun last year. The problem is basically to find a suitable variety of dura and its suitable environment meaning by environment the combination of soil-vegetation types previous to sowing, cultural methods and crop associations. The Azande grow little dura; either a ratooning variety added in small pro-

portion to one of their eleusine associations; or ecologically specialised patches on termitaria. When seeking methods of increasing dura production there was the choice between two associations practised in neighbouring areas, a) dura broadcast through cowpeas after an opening with burning as practiced by the Abakas of Meridi on open grass-bush land and b) dura broadcast together with cowpeas through grass, an adaptation by some Azandes of Ibba sub-district.

Lay out. Since the broadcast-through-grass association gave the better results last year, only this method was used. The grass was tall grass of a one year old fallow after two years cultivation. Besides cowpeas the associate crops were soya beans, green grams and none (pure stand dura — control). Dura varieties were Gode, Mangbagu (Azande rationing) and Commercial (probably identical with the Kirima of Ibba and Meridi). Sowing dates were 2.6 and 16.7.

Results. Stand and growth both were poor and yields of dura, as well as of the associate crops, were very low. This may be due to the use of the toria hoe instead of the Zande hoe which mixes the seed with the soil in a different manner. The Commercial Variety was completely sterile. The same sterility took place last year with variety Kirima and was also observed previously in other places, for instance Ndala variety in Kurukwata in 1947. It may be associated with the amount and distribution of rainfall since dura plays a very small part in native cultivation in areas with 1300 mms. rainfall or more, whereas to the north and east where rainfall is less, it is the main cereal crop.

The introduction of dura into the heavy rainfall area is however desirable, as a partial substitute for eleusine, the tedious harvest of which clashes with cotton picking.

HYPTIS OBSERVATION PLOTS.

Object. *Hyptis spicigera* is universally grown in Zande District in association with eleusine. Because of its possible value as an oil crop for the Nzara oil mill, observation plots were established to determine average yields of *Hyptis* in pure stand.

Layout. Plots were laid out on first year land (a total of about 6000 sq. m.). The land was opened according to standard practice for groundnuts, (planted on 30.4 and harvested on 4.8.51). *Hyptis* was broadcast on 4.8, resown after 12 days, hand weeded after 35 and 66 days and harvested on 5.1.1952, 154 days after sowing. In addition one small plot was sown at the same time on the same field but immediately following opening with burning.

Germination was good and the crop was free of both disease and pests, and looked superb before harvest. Yields however averaged only 240 kg/ha, less than that of an average sesame crop. This probably means that *Hyptis* is intrinsically a low yielder since observations do not support the idea that yields were depressed by too dense a stand of a crop accustomed to the wider spacing of an association.

Samples have been sent for oil analysis,

APPLICATION OF FERTILIZERS TO BUSH FALLOW.

Object. Application of phosphate to the cotton crop in 1948 failed to give an increase in yield. This trial was a preliminary investigation of the subsequent availability to crops of fertilisers added to bush fallow in the year prior to sowing.

Lay Out and Execution. Three phosphate treatments a) control b) Rock phosphate, ex Uganda and c) Silico phosphate ex Uganda both at 80 rotls total P_2O_5 per feddan were replicated five times in radomised blocks. Plots were split for a comparison of nitrogen versus no nitrogen at a rate of 40 rotls N per feddan.

Fertilisers were broadcast into thick secondary bush with little grass in August 1950 and groundnuts were planted in the middle of April 1951, harvested after 100 days and succeeded by broadcast eleusine.

Observations. Differences in vegetative growth between groundnuts on plots with and without nitrogen were soon observable; on the 75th. day the plots which had received nitrogen could be clearly picked out by their dark green vigorous growth compared to the higher shade of untreated plots. Phosphate treated plots could not be so distinguished.

Yields. Showed a 9.8 per cent increase for plots with nitrogen and 1.7 and 15.1 per cent for rock and silico phosphate respectively. However neither the main treatments nor interactions were significant at $P = 0.05$. Variability was high, the coefficient of variability for sub plots being 18.3 per cent (Table 4.).

Table 4.
Fertilizer to Bush Experiment.
Yields of Groundnuts as percentage of General Average.

Treatment	No. Phosphate	Rock Phosphate	Silico Phosphate	Average
No Nitrogen	92.6	89.6	103.0	95.1
Nitrogen	96.2	102.6	116.1	104.9
Average	94.4	96.1	109.5	100.0

General Average = 1587 Kg/hectare
(1481 r.p.f.) dry nuts.

Standard Error : Phosphate treatments = 10.7 per cent General Average
Standard Error : Nitrogen treatments = 4.7 per cent General Average
Standard Error : Interaction N x P = 8.2 per cent General Average

Eleusine gave no apparent response to either phosphate or nitrogen. (Table 5).

The plot will be cropped with cotton in 1952/53.

This experiment seems worth pursuing and additional experiments have been laid down to compare direct application of nitrogen, phosphate and potash to a crop with their application into grass and light bush fallows one year prior to cultivation.

Table 5.

Fertilizer to Bush Experiment.

Yields of Eleusine as percentage of General Average.

Treatment	No. Phosphate	Rock Phosphate	Silico Phosphate	Average
No Nitrogen	97.3	105.1	92.6	98.3
Nitrogen	103.2	101.6	100.0	101.6
Average	100.3	103.4	96.3	100.0

General Average = 1846 Kg/hectare

(1722 r.p.f.) of grain.

SOIL VARIABILITY TRIAL.

A soil variability trial was undertaken, to determine,

- variation of crop yields on very small sub plots of 3.0 x 2.7 m. and thence,
- optimum size and shape of plots and suitable number of replicates for future trials,
- whether records of termite mounds and tree stumps can be used to reduce variability by analysis of covariance.

An experimental strip was laid out in 924 plots each 3.0 x 2.7 m. and cropped with groundnuts. Eleusine followed the groundnuts but was so badly damaged by wild pigs that *Phaseolus angularis* was sown in its place.

Both groundnuts and beans yield good, easily measured crops. Records were taken of plot yields, number of tree stumps, and area of termitaria and ironstone outcrops per plot. Some observations were made on the influence of termitaria in delaying leaf shedding and maturity of *Phaseolus*.

The statistician, after analysing the figures, made the recommendations given on p. 50.

Catena Fertility Trial.

CROP YIELDS.

Object and lay out of this experiment were described in Annual Report 1949/50 page 137.

Cropping on the Catena Fertility Trial in the last three years has been :

Years	Rotation		
	A	B	C
1949	Cotton	Groundnuts—Eleusine	Maize/eleusine.
1950	Groundnuts—eleusine	Cotton	Cotton
1951	Cotton	Sesame	Groundnuts—eleusine

Averages of yields of the three main crops for the whole experiments through the three years are given in Table 7.

Table 7.
Catena Fertility Trial.
Yields in Kg/ha.

Years				Cotton	Groundnuts	Eleusine after Groundnuts	Eleusine with Maize
1949	...	...	...	1100	839	1098	
1950	...	...	...	1210	1253	1282	467
1951	...	...	...	656	945	1365	

It is quite likely that these encouraging results are due to the soil conservation inherent in customary methods, to which we have clung throughout. According to our observations we have even left more of the coppice-producing tree stumps intact than in local practice. It should be mentioned that 1951 was in general a poor year for cotton but a good year for eleusine.

ECOLOGICAL WORK.

(1) *Natural Vegetation.*

In March-April 1949 natural vegetation plots were treated in the same fashion as the plots under cultivation. Grass was hoed, trees cut back to one metre and the whole burnt. Plots were then allowed to regenerate without interference. They were fire protected but in February 1951 a bush fire, sweeping in from outside the experiment, burnt the natural vegetation plots of blocks 1 — 4.

Blocks 1 — 2, the norite hill, which were dominantly grass species, suffered a serious setback, seedlings and much of the ratoon growth being destroyed: At the beginning of the 1952 rains, plots were *Imperata cylindrica*-dominant with very sparse and poor coppice.

On the ironstone catena (block 4 — 25) regeneration everywhere followed the same pattern, namely suppression of tall grasses, mainly by shrub and scrambler growth, not however to the detriment of tree species. After three years, grasses dominate only those plots in ironstone gravel at the top of the ridge and on suspected sites of old dwellings, where *Imperata* persists in patches as a dominant.

Botanical analyses of the more important species of three natural vegetation plots from blocks 3 and 18, after one, two and three years' regeneration, have been made but are not included here.

Plots on block 3 are on rich colluvial soil in the depression at the base of the norite outcrop and the ironstone ridge, and had a thick regenerating secondary bush cover before the initial burning. *Ficus vallis-choudae* and *Vernonia thompsonii* came away quickly from ratoon growth. Regeneration was so rapid that even the fire of February 1951 had no appreciable effect on shrub and tree growth. By February 1952 the plots could be considered fire proof. Very little tall grass survives and even the shade-tolerant *Setaria sulcata* is only occasional.

Block 18 is an example of the generation on average ironstone soil of typical grass-woodland. Grasses dominated for the first two years but by the third year were largely suppressed by a dense *Fluggea* thicket and the shading effect of *F. vallis-choudae* with its spreading growth habit and by the scrambler species. Tree growth characteristic of the area is coming away through the shrub layer.

The fire resistance of block 18 was demonstrated on 12th. March 1952, when an attempt was made to fire the plots. All that was achieved was a creeping fire, across the debris of dead leaves, which could be easily controlled and here and there even petered out of its own accord. These observations have a direct bearing on the practical aspect of Hedge Strip Farming, the proposed rotational plan for Zande Agriculture with fire protected fallows.

(2) Fallow Regeneration After Two Years Cropping.

The first plots of rotations A, B and C reverted to fallow at the end of the 1950/51 crop season. Ratoon growth of bush in cotton plots of rotations B and C in the 1950/51 crop season was generally much better than that of eleusine plots of rotation A. However after one year's fallow no difference in regeneration between rotations was observable.

On Blocks 1 and 2 where ratoon growth was light, the fallow is still dominantly *Imperata* due to the accidental fire of February 1951.

In the bottom of the depression (Blocks 3,4) reversion to bush is rapid, despite all but two of the plots being burnt. Tree, shrub and scrambler growth, mainly *F. vallis-choudae*, *Vernonia*, *Fluggea*, *Phyllanthus floribundus* and *Harrisonia* dominate the fallow and are suppressing *Imperata*.

On Blocks 12-15, on the gradual slope up to the top of the ironstone ridge, and Blocks 23-24, at the lower end of the slope to gallery forest, fallow regeneration is equally rapid. *Fluggea* and scramblers are locally dominant, already providing an appreciable shade which will probably lead to total suppression of the tall grasses within two more years

Block 25, on the verge of the gallery forest has a dominantly herb fallow, *Triumfetta rhomboidea* being frequent.

Over the rest of the fallows, *Imperata* is locally dominant and in competition with bush and scrambler growth.

Tree species; *Comretum* spp, *Acacia*, *Vitex Anogeissus*, *Albizzia Trema*, *Stereospermum*, *Grewia*, *Sarcocephalus*, *Bauhinia*; and the tall grasses, mainly *Rottboellia*, *Beckeropsis* and *Panicum maximum* occur throughout the fallows.

The colonising species most effective in the suppression of *Imperata* appear to be *F. vallis-choudae* and *V. thompsonii* on the richer soils, scrambling *Combretum* on the savannah and *Fluggea microcarpa*, *Phyllanthus floribundus* and *Harrisonia abyssinica* throughout.

(3) Fallow weed growth after three years Cropping.

After three years of cultivation ratoon growth was comparatively light on all fallows. It was mainly composed of species of *Ficus* and *Combretum* with *Grewia mollis*, *Sarcocephalus esculentus*, *Acacia stenocarpa* and *Bauhinia reticulata* occasional *Fluggea* was everywhere frequent. On Blocks 14, 15, 16, 17 the dominant ratoon was *Combretum racemosum*.

In February on the cotton fallows, as a result of cleaning, herb and grass growth was negligible except on the norite outcrop, where *Imperata* was dominant. Elsewhere *Imperata* was beginning to come up on all fallows and, prior to sowing groundnuts, was rapidly establishing dominance on plots.

Sesame and eleusine fallows, in February, were mainly *Imperata*. Owing to the bad germination and consequent patchiness of the sesame most fallows of rotation B had a heavy dominant stand of *Imperata*, whilst after eleusine it was frequent but lacked the same density of stand. *Blumea auritia*, *Bidens pilosa*, *Eragrostis* spp., *Cyperus* spp. and an unidentified grass 'Rende' were frequent throughout both types of fallow.

Work on Soil.

Soil sampling.

Most of our soil sampling since 1948 has been done in conjunction with the Catena Fertility Trial. Results of analyses which have been done at Wad Medani have so far done little to elucidate the fertility status of the soil.

Samples are being sent to Rothamsted, Madrid and Wageningen for various special analyses. Government Geologist Khartoum has given us a valuable mineralogical analysis of the silt fractions.

Soil Moistures.

Work in the newly started laboratory has been confined to measurements of soil moistures and water penetration.

During the dry season of 1951/52, 52 profiles were analysed at depths of 0, 30, 60, 90 and 120 cm., 29 of them without and 23 with application of artificial rain. (Three analyses per sample, total number of analyses 750). As expected, drying out is quickest under forest growth, next under grass and crops which wither in December, and slowest under conditions of dry farming.

Drying out is much slower on a juvenile norite profile, than on a mature ironstone profile, suggesting a higher field capacity and less percolation on the former, which may partly explain the higher productivity of norite soils in terms of permanent plantations.

Water penetration is extremely rapid, a rain of 50 mm. being able to reach depths of 120 cm. in a few hours. It is also erratic and, as expected, follows channels of the most porous materials. Rains of 20 mm. could be traced in the first 30 cm. layer and rains of 50 mm. to a depth of 120 cm.

Water Table.

Pentad and daily observations were made in deep pits along the Catena Fertility Trial on the fluctuations of the water table, with the result that down to depths of 8 m. no formation of a water table, in the sense of water filling macropores and standing in a pit has been found. Only pits, where local imperviousness was suspected, had some water standing at the bottom for short periods after very heavy rains. These observations also show the great porosity of these soils and the very rapid movements of water which occur.

RESEARCH DIVISION LIBRARY

by *W. J. Plumble*

The year was one of consolidation and, in general, continuation of work done in the preceding two years. There was a very marked increase in use made of the Library and a large increase over 1950 in the number of publications received. In the latter half of the year the volume of work became more than could be handled by the staff available and a result certain routine processes lapsed or were indifferently carried out and the Accessions Bulletin had to be discontinued. Apart from this the Library was able to give an improved service; and as far as internal organization was concerned it began to function with reasonable efficiency. The main needs for the future are trained staff, more equipment, a more comprehensive stock, and space to expand. The year's activities may be summarized as follows:—

1. ACQUISITION OF STOCK.

Serials (This includes journals but excludes annual reports). The number of titles received at the end of the year was 232. The actual number of parts received was 2,012; of these, 530 were distributed to sections and outstations. The increase since 1948 is as follows:—

1948	1949	1950	1951
104	131	181	232

Pamphlets. The year's accessions totalled 4,176 of which about 3,000 were taken over from the Entomological Section. The intake compared with other years was as follows:—

1948	1949	1950	1951
336	1,343	931	4,176

The pamphlet collection contained approximately 16,376 items at the end of December.

Books. The new budget allowed for considerable improvement of the bookstock, and 269 books were bought in the course of 1951 as compared with 164 in 1950. In addition to buying books published in 1950 and 1951 it was possible to fill certain gaps in the stock, particularly in entomology, mycology and library reference works. The total bookstock at the end of December was 2,601.

Photostats. Increased use was made of the Science Museum library's Overseas Photostats Service. Photostats were also obtained from the United States Department of Agriculture Library, ASLIB, the Commonwealth Institute of Entomology, and a commercial firm in Cairo.

Silviculturist's Library. Eighteen journals were obtained for this library, and at the end of the year most of the books ordered had arrived.

2. BINDING OF JOURNALS.

190 "Easibinders" ordered in 1950 were received, and a further 507 ordered. Preparation of binding-sheets for "Easibinders" demands great care and accuracy, and it has been necessary for one assistant to work on this job almost continuously for several months. He has dealt with 8,378 parts of periodicals. So far, owing to lack of time, it has been impossible to attempt to secure missing back numbers, but it is hoped to deal with these in 1952.

3. CLASSIFICATION AND CATALOGUES.

Author and subject catalogues. These contained 31,253 entries at the end of the year. Of these 15,856 were made and inserted during 1951. Pamphlets from the Entomological Section were classified and catalogued; so were all other acquisitions; uncatalogued material concerning agriculture in general (including annual reports), botany (including mycology), plant diseases and control, and plant physiology, was also catalogued. It is again true to say that progress in cataloguing contributed more than any other factor to the better functioning of the Library during the year.

Duplicated catalogue. A short list of recent pamphlets and articles dealing with cotton and sorghum was issued in January.

Fiches Bibliographiques. These comprise an abstract service covering current literature in the field of tropical and subtropical constantly up-to-date, covers the period January 1950 onwards. The service is provided by I.N.E.A.C. for its libraries in Belgian Congo but it seems likely that it may also be of considerable value to agricultural research staff in the Sudan.

4. USE MADE OF LIBRARY.

Loans. Publications were lent to 130 individuals as compared with 101 the previous year. New research staff, in particular, made vigorous use of the Library, and more material than formerly was lent to field staff, especially in Equatoria.

Information work. Bibliographies on rice, coffee, salt-tolerance of the cotton plant and a few other subjects were compiled. The Library was used as a fact-finding centre to a greater extent than in other years, enquiries covering a wide range of subjects. Work of this kind is more or less continuous, and such inquiries can easily be answered over the telephone provided that the library staff know where to look for information. Not all enquiries, however, can be handled quickly; sometimes a systematic search for a bit of information has to be made, and this may take hours.

5. CO-OPERATION WITH OTHER DEPARTMENTS AND NON-GOVERNMENT INSTITUTIONS.

The loan of publications to the Division by the Newbold Library, Wellcome Chemical Laboratories, the Forests Office and the Geological Survey, is gratefully acknowledged.

So far as loans in an outward direction are concerned the Research Division Library benefited a much wider circle than the staff of the Division. Publications were lent to the Field Division, Mechanical Division, Equatoria Projects Board, Jonglei Investigation Team, Veterinary Service, Irrigation Department, Sudan Gezira Board, School of Agriculture, Geological Survey, Wellcome Chemical Laboratories, Pest Control, Ltd., Imperial Chemical Laboratories, Horticultural Staff Administrative staff, and to a few private individuals.

The library of the Irrigation Department was visited and a report made regarding its re-organization. The librarian served as a co-opted member on Wad Medani Town Council Library Committee.

6. EQUIPMENT.

During the year 130 box-files, a Kardex cabinet, and some cataloguing equipment were obtained. Urgently needed "Simplex" steel shelving had arrived in the country in November but had not been delivered by the end of December.

7. STAFF.

An Arts diplomate of Gordon Memorial College, was appointed assistant librarian w.e.f. 1st April, 1951. Throughout the year the other staff consisted of one temporary Scale J clerk and one part-time typist and, in the school holidays, any secondary school boys who could be secured. In December two new posts were approved for the Library, and the establishment became :—

- 1 Librarian.
- 1 Assistant Librarian.
2. Technical Assistants.

Staff training. A course of 14 lessons was prepared for the assistant librarian; and in November he spent a few days visiting other libraries in the Three Towns. Owing to lack of trained staff it was necessary for the librarian and assistant staff to work together closely throughout the year, so that informal training of an elementary kind was continuous. If there is to be efficiency in the Library in future, even of the present standard, it will be necessary for at least two members of the staff to undergo overseas training up to intermediate professional level within the next five years.

